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JoGH editors and editorial board members are independent researchers based at academic institutions, thus being well placed to provide professional evaluation of the key topics and ongoing activities and programs.

PART TWO

Journal of Global Health: The Mission Statement

China managed to reduce its child mortality by two thirds between 1990 and 2006, thus achieving Millennium development Goal 4 nearly a decade before the deadline in 2015 that was suggested by the United Nations. This stunning success, given country's population, was a combined result of economic and social development, clear and progressive health policies, improved nutrition and micronutrient supplementation, development of China's health system, increased coverage and quality of implementation of life–saving interventions such as vaccines and antibiotics.

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The *Journal*'s mission is to serve the community of researchers, funding agencies, international organizations, policymakers and other stakeholders in the field of international health by:

- presenting important news from all world regions, key organizations and resources for global health and development;
- providing an independent assessment of the key issues that dominated the previous semester in the field of global health and development;
- publishing high-quality peer-reviewed original research and providing objective reviews of global health and development issues;
- allowing independent authors and stakeholders to voice their personal opinions on issues in global health.

Each issue is dedicated to a specific theme, which is introduced in the editorial and in one or more viewpoints and related articles. The news section brings up to five news items, selected by the *Journal*'s editorial team, relevant to seven regions of the world, seven international agencies and seven key resources important to human population health and development.

We particularly welcome submissions addressing persisting inequities in human health and development globally and within regions. We encourage content that could assist international organizations to align their investments in health research and development with objective measurements or estimates the disease burden or health problems that they aim to address. Finally, we promote submissions that highlight or analyse particularly successful or harmful practices in management of the key resources important for human population health and development.

All editors and editorial board members of the *Journal* are independent health professionals based at academic institutions or international public organisations and so are well placed to provide objective professional evaluation of key topics and ongoing activities and programs. We aim to stay true to principles of not-for-profit work, open knowledge and free publishing, and independence of academic thought from commercial or political constraints and influences. Join us in this publishing effort to provide evidence base for global health!

March 7, 2011 — The Editors, *Journal of Global Health*

journal of global health

PAPERS

Fukushima after the Great East Japan Earthquake: lessons for developing responsive and resilient health systems

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Background On 11 March 2011, the Great East Japan Earthquake, followed by a tsunami and nuclear–reactor meltdowns, produced one of the most severe disasters in the history of Japan. The adverse impact of this 'triple disaster' on the health of local populations and the health system was substantial. In this study we examine population–level health indicator changes that accompanied the disaster, and discuss options for re–designing Fukushima's health system, and by extension that of Japan, to enhance its responsiveness and resilience to current and future shocks.

Methods We used country–level (Japan–average) or prefecture–level data (2005–2014) available from the portal site of Official Statistics of Japan for Fukushima, Miyagi, and Iwate, the prefectures that were most affected by the disaster, to compare trends before (2005–2010) and after (2011–2014) the 'disaster'. We made time–trend line plots to describe changes over time in age–adjusted cause–specific mortality rates in each prefecture.

Findings All three prefectures, and in particular Fukushima, had lower socio–economic indicators, an older population, lower productivity and gross domestic product per capita, and less higher–level industry than the Japan average. All three prefectures were 'medically underserved', with fewer physicians, nurses, ambulance calls and clinics per 100 000 residents than the Japan average. Even before the disaster, age–adjusted all–cause mortality in Fukushima was in general higher than the national rates. After the triple disaster we found that the mortality rate due to myocardial infarction increased substantially in Fukushima while it decreased nationwide. Compared to Japan average, spikes in mortality due to lung disease (all three prefectures), stroke (Iwate and Miyagi), and all–cause mortality (Miyagi and Fukushima) were also observed post–disaster. The cause–specific mortality rate from cancer followed similar trends in all three prefectures to those in Japan as a whole. Although we found a sharp rise in ambulance calls in Iwate and Miyagi, we did not see such a rise in Fukushima: a finding which may indicate limited responsiveness to acute demand because of pre–existing restricted capacity in emergency ambulance services.

Conclusions We analyze changes in indicators of health and health systems infrastructure in Fukushima before and five years following the disaster, and explored health systems' strengths and vulnerabilities. Spikes in mortality rates for selected non–infectious conditions common among older individuals were observed compared to the national trends. The results suggest that poorer reserves in the health care delivery system in Fukushima limited its capacity to effectively meet sudden unexpected increases in demand generated by the disaster.

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On March 11th 2011, a massive earthquake, the Great East Japan Earthquake, followed by a tsunami, and tsunami damage–related nuclear–reactor meltdowns produced one of the most severe disasters in the history of Japan [1]. Among all of Japan's prefectures, Fukushima was the most severely affected by this "triple disaster (earthquake, tsunami, and nuclear meltdown)" [2]. The adverse impact of the triple disaster on the health of local populations and on the health system was substantial, with destruction of infrastructure (including hospitals, clinics and emergency transportation), homes and lives.

In Fukushima, nearly 3770 people died in the "disaster", and many of those deaths were caused by the tsunami [3]. More than 18 030 housing facilities were completely destroyed, and 75 159 were partially destroyed. The total cost of the damage to public facilities was estimated at 599.4 billion yen (equivalent to US$ 5.2 billion in 2017 exchange rates) [4]. At the time of the disaster, the Fukushima Daiichi nuclear power station was hit by a huge tsunami. The tsunami induced damage led to a series of events that triggered core meltdowns. Radioactive materials leaking from the plant forced people who had lived nearby to evacuate their homes. The Japanese government decided to restrict access to nearby areas and about 108 000 people were still considered to be displaced evacuees as of July 2015, including 63 000 inside Fukushima prefecture but not in their original homes. Faced with this surge of need and demand for health care, the capacity of health systems of Fukushima and the other most–affected nearby prefectures may have been exceeded. However, to date, no study has been undertaken to examine the effect of the triple disaster on the health system in Fukushima and the health system response.

This study examines changes in population–level health indicators before and after the triple disaster to ascertain the effect of the triple disaster on population health and the health system in Fukushima and surrounding prefectures, and discusses options for re–designing the health system to enhance its responsiveness and resilience to current and future shocks.

METHODS

Setting and data sources

We used publicly available data, data from government sources, and published literature for Japan overall and for Fukushima, Miyagi and Iwate – the prefectures that were most affected by the Great East Japan Earthquake. All three prefectures of Fukushima, Miyagi and Iwate are in the Tohoku region, which is known for being socio–economically less well developed compared to other regions of Japan.

Data for a predetermined list of population, health systems, and outcome indicators were collected for Japan overall (average) and prefectural–level aggregates, further delineated below. Our main source of data was the website of Official Statistics of Japan, managed by the National Statistics Center [4]. These data are officially compiled and aggregated from national surveys and administrative registers by the Japanese government and made available at the website on a quarterly or annual basis. We confined our study to time period 2005–2014 for which data were available for most indicators and to span the time before (2005–2010) and after (2011–2014) the disaster.

Population indicators

To analyze contextual characteristics in Fukushima and other prefectures, we used demographic and socio–economic indicators, including: population size, population density, percentage of people over 65 years, percentage of productive population, fertility rate, real gross domestic product (GDP), unemployment proportion, job category, crime rate and number of evacuees due to the disaster. Those indicators were measured by surveys of the Japanese Ministry of Internal Affairs and Communications [5].

Health system indicators

To assess health system factors that might affect mortality rates, we used the following supply–side indicators: number of hospitals, number of clinics, number of physicians, number of nurses, number of outpatient visits number of hospitalizations, number of ambulance calls, and health expenditure per capita. Those indicators were measured by Japanese Ministry of Health, Labour and Welfare surveys [6].

Health outcome indicators

Our main health outcome indicators were cause–specific mortality rates, which are measured regularly through the survey of vital statistics in Japan [7]. The causes of death of greatest interest were: all–

cause mortality, and that from myocardial infarction, cerebrovascular disease, cancer, lung disease, and suicide.

We reasoned a priori that cardiovascular mortality and stroke might be acutely reactive to the stress of the disaster, social and physical dislocations, as might suicide in the face of great personal and physical losses suffered. Similarly, marginally compensated chronic pulmonary disease and/or reactive airway disease might also respond to the altered circumstances imposed on the disease. Cancer mortality, however, might not show an acute change, since cancers might have a long premorbid phase. We used age–adjusted cause–specific mortality rates based on the model population of Japan in 1985 [8].

Analyses

All quantitative data were analyzed using Stata v.13 (StataCorp. 2013. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP, USA). We analyzed all indicators before and after the disaster to produce descriptive statistics and to establish a time–trend line plot to examine changes over time (2005–2014) and to compare the trends before (2005–2010) and after (2011–2014) the disaster in Japan (using Japan)–average, Fukushima, Miyagi and Iwate.

RESULTS

Changes in population indicators

Table 1 displays demographic and socio–economic indicators before and after the triple disaster. Real GDP per capita in 2010, before the disaster, was 3.8, 3.5, 3.3 million yen in Fukushima, Miyagi and Iwate, respectively, compared to 4.0 million yen for Japan overall. Elderly over 65 years of age represented 25.0%, 22.3%, and 27.2% of the population respectively in Fukushima, Miyagi and Iwate compared to 23.0% in Japan overall. A smaller proportion of the population in each of the three prefectures participated in jobs in "high–level industry" (**Table 1**).

In Fukushima, the relative decline in the population level after the disaster was greater than that observed in other prefectures: 3.9% between 2015 and 2010 compared to 1.29% in Miyagi, 2.9% in Iwate, and 0.53% in Japan overall. Compared to the trends observed in the rest of the country, the age structure in Fukushima is changing more rapidly, with an increasing proportion of people over the age of 65 years after the disaster reaching 26.9% of the total population in the prefecture in 2013, compared with 25.0% in 2010.

Fukushima's economic indicators as measured by average real GDP and income per person remained flat after the triple disaster, but the industrial production index, which is used to track the production of

Table1. Population and health system indicators of Fukushima, Iwate, Miyagi and Japan before and after the earthquake*

Indicators	Fukushima		Miyagi		Iwate		Japan	
	Before	After	Before	After	Before	After	Before	After
Population (100 000 people)	20.5	19.7	23.3	23.0	13.5	13.1	1270.6	1263.9
Population density (/km^2)	147.2	141.2	322.3	319.5	87.1	84.8	343.4	341.3
Percentage of elderly over 65 (%)	25.0	26.9	22.3	23.8	27.2	28.7	23.0	25.1
Percentage of productive population aged 15–64 (%)	62.5	60.4	66.0	63.4	61.4	59.0	65.8	62.1
Fertility rate (per 1000 people)	8.0	7.5	8.2	8.2	7.4	7.2	8.5	8.2
Total fertility rate	1.49	1.53	1.25	1.34	1.37	1.46	1.37	1.43
Real GDP (trillion yen)	7.6	7.6	8.2	9.1	4.4	4.7	512.5	517.5
Real GDP per capita (million yen)	3.8	3.9	3.5	3.8	3.3	3.6	4.0	4.1
Unemployment proportion (%)	5.1	3.6	5.7	4.1	5.1	3.3	5.1	4.0
Percentage of job category:								
Primary industry (%)	7.6	–	5.0	–	12.0	–	4.0	–
Secondary industry (%)	29.2	–	22.1	–	24.3	–	23.7	–
Tertiary industry (%)	60.0	–	70.5	–	62.3	–	66.5	–
Crime rate (per 100 000 people)	6.7	5.3	10.0	10.1	5.9	6.0	11.0	11.1
Number of evacuees to the other areas in the same prefecture (per 1000 people)	–	60.6	–	53.9	–	24.7	–	190.5
Number of evacuees to the other prefectures (per 1000 people)		44.1		6.7		1.5		–

*Data before the disaster were measured in 2010. Data after the disaster were measured in 2012 (real GDP), 2015 (number of evacuees) or 2013 (other indicators). We extracted data from the portal site of Official Statistics of Japan [8].

manufacturing industries, declined, and by 2014 had not recovered to the pre–disaster levels achieved [9]. By contrast, in Miyagi, Iwate and Japan overall, average real GDP and income per person rose, while unemployment rates declined, between 2010 and 2012. Fukushima crime rates, which were already low compared to Japan as a whole, remained low and actually improved after the disaster.

By 2015, four years after the disaster, 190 000 people had remained as evacuees (located to prefectures all over Japan), and were unable to return to the coastal areas most affected by the disaster. This situation was worse for those from Fukushima, due to the nuclear power plant accident. Compared to Miyagi and Iwate, Fukushima had the highest number of evacuees residing in the same prefecture (60 600), and the highest number of evacuees located to other prefectures of Japan (44 100).

Changes in health system indicators

All three prefectures studied were "medically underserved" before the disaster, with fewer physicians, nurses, ambulance calls and clinics per 100 000 residents compared with Japan averages.

Figure 1 shows time–trends for indicators related to health system capacity. The number of hospitals and clinics declined in Fukushima immediately after the disaster – a reflection of the physical destruction of facilities. The number of physicians and nurses in hospitals pre–disaster already was lower in Fukushima compared with the Japan–average (a deficit of 30 physicians/100 000 people and 120 nurses/100 000 people). Soon after the disaster, teams of health professionals from other prefectures were dispatched to the afflicted areas. Long–term efforts, however, are still needed to address the structural shortage of health care workers in Fukushima at present (see **Figure 1**, panels 2C and 2D).

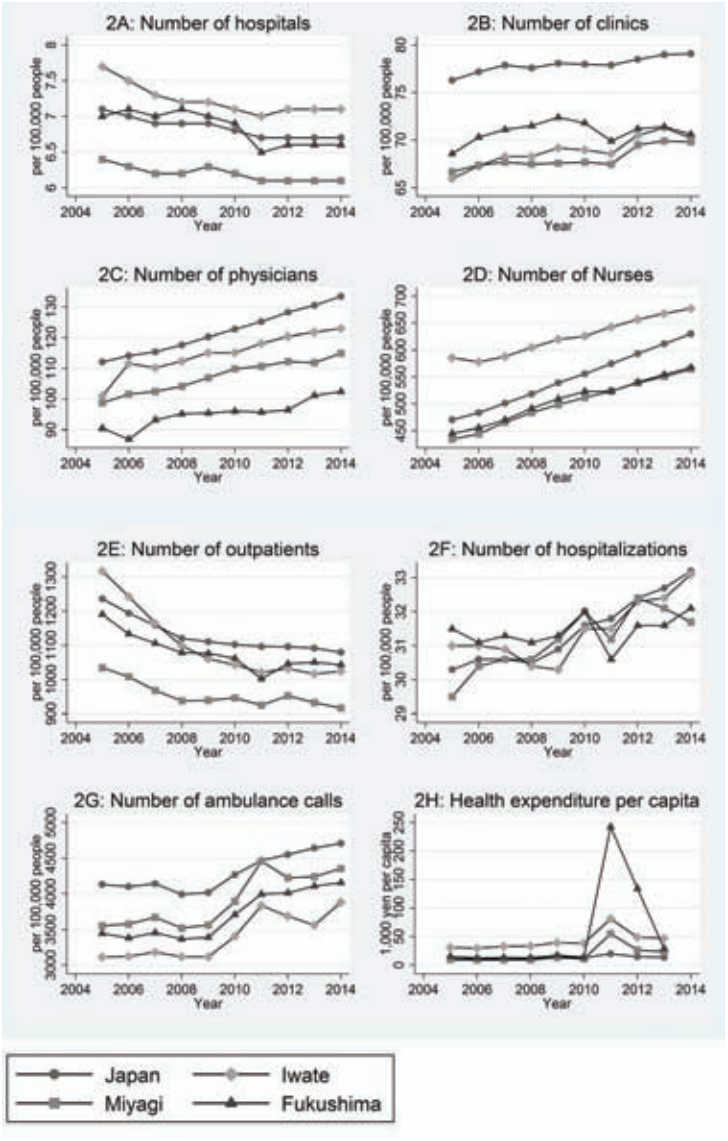


Figure 1. Time–trend in health system indicators 5 years after the disaster. 2A: Number of hospitals. 2B: Number of clinics. 2C: Number of physicians. 2D: Number of registered nurses. 2E: Number of outpatients. 2F: Number of hospitalizations. 2G: Number of ambulance call. 2H: Health expenditure per capita.

In terms of service utilization in the health system, the number of outpatient visits and hospitalizations declined immediately after the disaster, especially in Fukushima and Miyagi. This decline may reflect the loss of medical facilities (hospitals and clinics). Health expenditures, however, rose dramatically in Fukushima just after the disaster. A breakdown of the rising health expenditures reveals that major capital investments related to reconstruction projects for environmental health (the construction of decontamination facilities needed to deal with radiation exposure) and expenditures for provision of medical care (repair and reconstruction of hospitals and clinics in coastal areas, as well as for recruitment of health care workers) constituted the main elements of the rise expenditures [9]. The number of ambulance calls increased gradually in Japan as a whole, a trend which may reflect the rising demand from increasing numbers of elderly patients in Japan's aging society [10]. Although we found a sharp rise in ambulance calls in Iwate and Miyagi, we did not see such a rise in Fukushima, in spite of it having a higher proportion of older persons in the prefecture's population compared to Iwate, Miyage and the rest of Japan. This 'flattening' in ambulance call rates in spite of an older population base might reflect the inability of the damaged emergency transportation system to respond to need.

Changes in health outcome indicators

Figure 2 displays time–trends in health indicators before (2005–2010) and after (2011–2015) the disaster in Fukushima, Miyagi, Iwate and the average indicators for Japan as a whole.

Even before the disaster, age–adjusted all–cause mortality in Fukushima was in general higher than the national average for Japan. The mortality in Japan in 2010 was 390 deaths per 100 000 population while in Fukushima that rate was 415, rising to 480 in 2011, but decreasing to 403 in 2012. We found a higher rise in mortality in Iwate from 418 deaths per 100 000 population in 2010 to 699 in 2011and in Miyagi from 386 deaths per 100 000 population to 713 in 2011 after the disaster.

While other cause–specific mortality rates, such as deaths due to cancer, show similar trends in Fukushima to those in Japan as a whole, after the disaster the mortality rate due to myocardial infarction (MI) increased substantially in Fukushima, while this rate decreased nationwide. Mortality rate due to MI in Fukushima also differed from the rates and trends in Iwate and Miyagi where reductions in mortality rates from MI were evident (see **Figure 2**, panel 1B).

In Fukushima, Miyagi and Iwate there were also sharp increase in the rates of mortality from lung diseases in 2011 (**Figure 2**, panel 1E). While, nationally and in Fukushima there were steep declines in the mortality rates from lung diseases in the period 2005 to 2010, in Fukushima there was a sharp rise observed from 47 deaths per 100 000 in 2010 to 54 deaths per 100 000 in 2011. From 2012, in the three study prefectures the mortality rates form lung disease re–established their downward trend.

The suicide rates (**Figure 2**, panel 1F) in the three prefectures appeared to be declining before the disaster as well as in Japan as a whole. There appears to have been no 'epidemic' of suicides temporally related to the disaster in the three prefectures. By simple inspection, there may have been an excess of suicides in 2009, but not in 2011, when there may have been a sharper rate of decline in the three prefectures.

Discussion

In the three affected prefectures of Fukushima, Miyake and Iwate in Japan, the Great East Japan Earthquake and its sequelae of a tsunami and nuclear reactor meltdown were responsible for major damage to persons and property. To our knowledge, this is the first paper to describe changes over time in multidi-

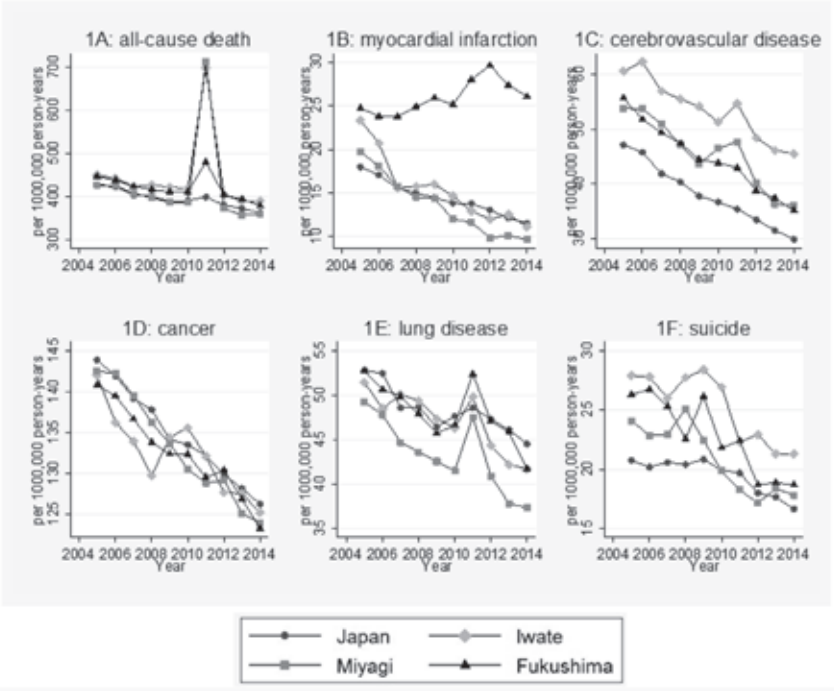


Figure 2. Time–trend in health outcome indicators 5 years after the disaster. 1A: Age–adjusted all–cause death rate. 1B: Age–adjusted death rate due to cardiovascular disease. 1C: Age–adjusted death rate due to cerebrovascular disease. 1D: Age–adjusted death rate due to cancer. 1E: Age–adjusted death rate due to lung disease. 1F: Age–adjusted death rate due to suicide.

mensional health and health system indicators for Fukushima and other affected prefectures in the period before (2005–2010) and five years after (2011–2014) the disaster.

By our observations, Fukushima, its residential populations, and those of its neighboring prefectures were already socio–economically and demographically vulnerable in 2011 to the destruction brought by the triple disaster. The health outcomes examined appear to show manifestations of the high burden of chronic conditions common in aging populations.

We found that mortality rate due to MI increased substantially in Fukushima, for example, while this rate decreased nationwide, but other cause–specific mortality rates such as deaths due to cancer show similar trends in Fukushima to those in Japan as a whole. Although we found a sharp rise in ambulance calls in Iwate and Miyagi, we did not see such a rise in Fukushima, which may indicate poor responsiveness of the health system in Fukushima, due to a limited capacity to respond to need/demand with emergency ambulance services. These results suggest that there were poorer reserves, and weaker emergency responsiveness and resilience of the health system in Fukushima than Iwate and Miyage. Hence, it was unable to meet the sudden and unexpected rise in demand for health services generated by the disaster.

Following the disaster, age–adjusted all–cause mortality in Fukushima and the two other prefectures affected by the disaster was higher than the average national rates. This difference could be attributed to health systems factors, such as poor quality of care and inadequate supply of resources in these prefectures, as well as the unique contextual factors in them (such as the socio–economic milieu), which might have magnified the adverse effects of the disaster, with the tsunami leading to widespread destruction of homes. Many people in the afflicted areas struggled with access to medications and treatments to effectively manage their chronic conditions, an adversity which could have resulted in excess premature deaths [11].

The observed high mortality rate due to MI in Fukushima may present a unique set of challenges for the health system in Fukushima. First, the shortage of physicians was more severe in Fukushima than in its neighboring prefectures. Second, and related to the first explanation, there were poorer reserves in health care delivery system as a whole in Fukushima, hindering an effective response to meet unexpected and sudden rise in demand generated by the disaster. Third, Fukushima has the third largest land–area among all prefectures in Japan, so it is likely that the time lapse for an effective response (for example as measured by 'pain onset–to–balloon time') for MIs was more likely to be longer than other prefectures. Fourth, the high rates of MI could reflect the changing demographic profiles in Fukushima, leading a relatively higher proportion of elderly residents as a result of younger and healthier people migrating out of the prefecture.

Mental health problems typically emerge after major disasters, but in the three prefectures affected by the disaster the suicide rates did not spike. It was reported that within days of the disaster there was a recognition by the government and local authorities of the psychological consequences of the events and 'mental health care response teams' were dispatched by the Ministry of Health, Labor and Welfare to the affected areas [12,13]. Risk factors for mental illness need continued attention, however [14]. A survey of self–reported mental health found that respondents felt a sense of "isolation" for at least 18 months after the disaster despite their participation in community–based programs [15].

There were also some striking and encouraging responses to the disaster, some from the health system, as it mobilized its remaining resources in unusual ways, and others from Japan's civil society and cultural practices generally. The undersupply of health care workers, largely as a result of geographic maldistribution, is an important issue affecting Japan's health system not only in Fukushima, but also elsewhere in rural Japan.

The aftermath of the triple disaster revealed social cohesion, as well as the strengths and deficiencies in the responsiveness and resilience of Japan's health system. The societal response and resilience to the disaster was exemplary: not only did the social fabric not 'tear,' the society appears to have been able to weave a stronger fabric to protect its members, especially the elderly and vulnerable [16]. Community–level social cohesion before the disaster was shown to be associated with lower risk of post–traumatic stress disorder, and after the disaster social cohesion was maintained and strengthened to increase community resilience after the disaster [17]. Social violence, witnessed in other countries in the aftermath of natural disasters, did not emerge in the affected areas of Japan. Crimes did not increase, Conversely, we report that crime rates in Fukushima declined from 6.7 per 100 000 people in 2010 to 5.3 per 100 000 in 2012.

Advances in information communications technology (ICT) played an important role in local community as alternative information source and communication platform. Voluntarism was evident – providing much needed additional human resources. Yet, the responsiveness of the health system was challenged, and its resilience came under pressure, as the health system tried to meet the ongoing needs of vulnerable

populations, in particular the elderly. Community resilience, which depends on local context and multi-layered process [18], was evident in Fukushima.

Responsiveness challenges in the disaster were related to effective and timely integration of community and hospital responses, speed of communication, managing varied messages emerging from official sources and the media, transport – with consequent adverse effect on supply chain management for critical supplies – and the shortage of health human resources. There was strong public demand for high levels of transparency in relation to the course of events, timely communication and effective information dissemination.

Japan is rapidly aging and in terms of average life expectancy is ahead of other countries. Demographic shifts in the disaster–affected prefectures of Fukushima, Miyagi and Iwate, are particularly apparent, requiring an appropriate health system response to this unfavorable shift. Challenges to the health system brought by an aging of the population – such as disability and multimorbidity [19] – should be given priority in the future. In fact, population aging is, in itself, an internal shock to health system. Increased need for medical care and long–term care resources for the elderly population will be a major challenge for the re–design of sustainable health systems [20].

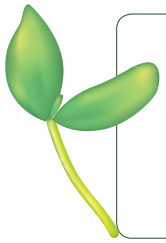
There are two significant limitations of this study. First, this is an ecological study using prefecture–level aggregated data. Socio–economic and demographics changed in the three study prefectures over time and those changes would affect both numerators and denominators in our analysis. For example, Fukushima is aging more rapidly with an increasing proportion of elderly people. This may be the result of many young families leaving Fukushima; for example, families who might be concerned about the long term effects of radiation exposure for their children. Second, we only used available data from the portal site of Official Statistics of Japan and were not able to secure individual level data on the affected and control populations. Third, the effect of the triple disaster on the health system of the affected prefectures may not be generalizable to other disasters. However, notwithstanding contextual differences, this unexpected major natural disaster revealed common problems for health systems that may be applicable to other prefectures of Japan. Even allowing for the methodological challenges faced by the study, reflecting on the lessons learned from Fukushima should be important when discussing options for re–designing health systems to enhance their responsiveness and resilience to major internal and external shocks.

In retrospect, several lessons emerge from the response of Fukushima to the triple disaster, ones that may inform health system transformations elsewhere to enhance responsiveness and resilience to shocks, but also in relation to managing wider social determinants and community aspects of disaster resilience. An expert group meeting in Fukushima under the auspices of the World Health Summit Regional Meeting in Japan in 2015 elaborated these lessons as follows [21]: Responsiveness can be enhanced by (i) establishing a local, regional and national framework for rapid information–sharing, decision–making and action; (ii) gathering timely information across sectors of government and industry for targeted action and dissemination to the public; (iii) creating sufficient reserves to rapidly mobilize and fill health system 'gaps' that emerge due to limited supply of critical resources and increased demand for resources immediately after a disaster; (iv) providing immediate access to transportation, communication, temporary shelter, clothing, and food to assure individual and population health security needs; (v) creating just–in–time management systems to deploy mobile heath teams and health workers in health systems; and (vi) integrating health system and social actions for a more comprehensive response. Resilience, on the other hand, the expert group concluded, can be developed and enhanced by (i) better monitoring the long–term effects of disasters, including mortality, disability, destitution, and social welfare in different population groups, especially the vulnerable, to inform current and future policies; (ii) establishing multi–sector action plans involving public agencies and the private sector; (iii) enabling community mobilization through social networks and building social capital; and (iv) developing and strengthening leadership at all levels of the health system to improve communication and inclusive decision making.

Fukushima illustrates the challenges faced by health systems in Japan and other countries globally, which are subject to rapidly changing contexts – as a result of swift demographic and epidemiological transitions (leading to population aging and a rapid rise of in the burden of chronic illness and disability), economic crises, ecological shocks from natural disasters and changing socio–cultural milieu – and have to respond and be resilient to the emerging challenges and shocks, while continuing to provide effective universal health coverage [22,23].

Contextual shocks and major disasters could happen anytime and anywhere worldwide, and their impact on health systems and health are globally relevant. Given the uncertainties, nothing less than transformative change is needed to create health systems in Japan and globally that are responsive and resil-

ient to future shocks and emerging contextual challenges, including the rapid aging of our societies and the multimorbidity and disability this transition brings [18]. The Fukushima triple disaster is not the first, and will not be the last such challenge we face globally. Learning from our experience must be the order of the day.



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Conflict of interest: The authors completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available upon request from the corresponding author), and declare no conflict of interest.

REFERENCES

1 Mimura N, Yasuhara K, Kawagoe S, Yokoki H, Kazama S. Damage from the Great East Japan Earthquake and Tsunami - a quick report. Mitig Adapt Strategies Glob Change. 2011;16:803-18. doi:10.1007/s11027-011-9297-7

2 Matsumoto M, Inoue K. Earthquake, tsunami, radiation leak, and crisis in rural health in Japan. Rural Remote Health. 2011;11:1759. Medline:21413825

3 Hayashi K, Tomita N. Lessons learned from the Great East Japan Earthquake: impact on child and adolescent health. Asia Pac J Public Health. 2012;24:681-8. Medline:22815307 doi:10.1177/1010539512453255

4 Government of Japan. Portal Site of Official Statistics of Japan. Available: http://www.e-stat.go.jp/SG1/estat/eStatTopPortalE.doc. Accessed: 10 November 2015.

5 Government of Japan. Ministry of Internal Affairs and Communications. Available: http://www.soumu.go.jp/english/index.html. Accessed: 30 March 2016.

6 Welcome to Ministry of Health. Labour and Welfare. Available: http://www.mhlw.go.jp/english/. Accessed: 30 March 2016.

7 Outline of Vital Statistics in Japan. [cited 2016 Mar 30]. Available: http://www.mhlw.go.jp/english/database/db-hw/outline/index.html. Accessed: 30 March 2016.

8 Ministry of Health, Labour and Welfare, Government of Japan. Age adjusted mortality rate. Available: http://www.mhlw.go.jp/toukei/saikin/hw/jinkou/other/00sibou/1.html. Accessed: 10 November 2015.

9 Prefecture F. Steps for Revitalization in Fukushima. 2015. Available: https://www.pref.fukushima.lg.jp/sec/11015b/fukkoukeikaku1151.html. Accessed: 12 November 2015.

10 Fire and Disaster Management Agency, Government of Japan. Annual Report on Rescue operations. [website in Japanese]. Available: http://www.fdma.go.jp/neuter/topics/fieldList9_3.html. Accessed: 15 November 2015.

11 Muramatsu N, Akiyama H. Japan: super-aging society preparing for the future. Gerontologist. 2011;51:425-32. Medline:21804114 doi:10.1093/geront/gnr067

12 Kim Y. Great East Japan Earthquake and early mental-health-care response. Psychiatry Clin Neurosci. 2011;65:539-48. Medline:22003986 doi:10.1111/j.1440-1819.2011.02270.x

13 Shultz JM, Kelly F, Forbes D, Verdeli H, Leon GR, Rosen A, et al. Triple Threat Trauma: evidence-based mental health response for the 2011 Japan Disaster. Prehosp Disaster Med. 2011;26:141-5. Medline:22107762 doi:10.1017/S1049023X11006364

14 Goodwin R, Takahashi M, Sun S, Gaines SO Jr. Modelling psychological responses to the Great East Japan Earthquake and Nuclear Incident. PLoS One. 2012;7:e37690. Medline:22666380 doi:10.1371/journal.pone.0037690

15 Nagata S, Matsunaga A, Teramoto C. Follow-up study of the general and mental health of people living in temporary housing at 10 and 20 months after the Great East Japan Earthquake. Jpn J Nurs Sci. 2015;12:162-5. Medline:25243491 doi:10.1111/jjns.12051

16 Aida J, Kawachi I, Subramanian SV, Kondo K. Disaster, social capital, and health. In: Global perspectives on social capital and health. Springer; 2013. Available: http://link.springer.com/chapter/10.1007/978-1-4614-7464-7_7. Accessed: 14 October 2016.

17 Hikichi H, Aida J, Tsuboya T, Kondo K, Kawachi I. Can community social cohesion prevent posttraumatic stress disorder in the aftermath of a disaster? A natural experiment from the 2011 Tohoku earthquake and tsunami. Am J Epidemiol. 2016;183:902-10. Medline:27026337 doi:10.1093/aje/kwv335

18 Wickes R, Zahnow R, Taylor M, Piquero AR. Neighborhood structure, social capital, and community resilience: longitudinal evidence from the 2011 Brisbane Flood Disaster. Soc Sci Q. 2015;96:330-53. doi:10.1111/ssqu.12144

19 Atun R, Gurol-Urganci I, Hone T, Pell L, Stokes J, Habicht T, et al. Shifting chronic disease management from hospitals to primary care in Estonian health system: analysis of national panel data. J Glob Health. 2016;6:020701. Medline:27648258 doi:10.7189/jogh.06.020701

20 Atun R. Transitioning health systems for multimorbidity. Lancet. 2015;386:721-2. Medline:26063473 doi:10.1016/S0140-6736(14)62254-6

21 World Health Summit. Impact. Available: http://www.worldhealthsummit.org/about-whs/impact.html#c25906. Accessed: 12 April 2016.

22 Atun R, Aydın S, Chakraborty S, Sümer S, Aran M, Gürol I, et al. Universal health coverage in Turkey: enhancement of equity. Lancet. 2013;382:65-99. Medline:23810020 doi:10.1016/S0140-6736(13)61051-X

23 Atun R, de Andrade LO, Almeida G, Cotlear D, Dmytraczenko T, Frenz P, et al. Health system reform and universal health coverage in Latin America. Lancet. 2015;385:1230-47. Medline:25458725 doi:10.1016/S0140-6736(14)61646-9

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PAPERS

User–fee–removal improves equity of children's health care utilization and reduces families' financial burden: evidence from Jamaica

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Background The impact of user–fee policies on the equity of health care utilization and households' financial burdens has remained largely unexplored in Latin American and the Caribbean, as well as in upper–middle–income countries. This paper assesses the short– and long–term impacts of Jamaica's user–fee–removal for children in 2007.

Methods This study utilizes 14 rounds of data from the Jamaica Survey of Living Conditions (JSLC) for the periods 1996 to 2012. JSLC is a national household survey, which collects data on health care utilization and among other purposes for planning. Interrupted time series (ITS) analysis was used to examine the immediate impact of the user–fee–removal policy on children's health care utilization and households' financial burdens, as well as the impact in the medium– to long–term.

Results Immediately following the implementation of user–fee–removal, the odds of seeking for health care if the children fell ill in the past 4 weeks increased by 97% (odds ratio 2.0, 95% confidence interval (CI) 1.1 to 3.5, $P=0.018$). In the short–term (2007–2008), health care utilization increased at a faster rate among children not in poverty than children in poverty; while this gap narrowed after 2008. There was minimal difference in health care utilization across wealth groups in the medium– to long–term. The household's financial burden (health expenditure as a share of household's non–food expenditures) reduced by 6 percentage points (95% CI: –11 to –1, $P=0.020$) right after the policy was implemented and kept at a low level. The difference in financial burden between children in poverty and children not in poverty shrunk rapidly after 2007 and remained small in subsequent years.

Conclusions User–fee–removal had a positive impact on promoting health care utilization among children and reducing their household health expenditures in Jamaica. The short–term and the medium– to long–term results have different indications: In the short–term, the policy deteriorated the equity of access to health care for children, while the equity status improved fast in the medium– to long–term.

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User fees refer to charges related to health services at the point of use. Such fees have been used to generate revenues for health care providers, reduce health care financing burden on governments and encourage clients to use health services more judiciously [1]. Historically, both the World Bank and the International Monetary Fund (IMF) have promoted user fees [2,3]. Yet evidence points to negative effects on equitable access to health services, and arguably increased households' health expenditures. Studies from Kenya, Tanzania, Burkina Faso, Niger, Democratic Republic of Congo, Leso-

tho, and Papua New Guinea have found that the introduction or increase of user fees significantly reduced health service utilization, with the poor and those in rural areas disproportionally disadvantaged because of the high financial burden [4-11]. Recognizing user fee as a barrier to access health services, the WHO passed resolutions 58.31 and 58.33 in 2005, urging member states to remove user fees in order to achieve Universal Health Coverage (UHC) [12]. UNICEF also committed to support the removal of user fees for children and pregnant women [13].

The Latin American and the Caribbean (LAC) countries have wavered between advocating or criticizing user fees over the past three decades. In the 1980s, user fees were introduced in Honduras, Jamaica, and Peru [14]. In the 2000s, Jamaica and Ecuador removed user fees in the public health sector [15]. Although a handful of studies have assessed the effects of user–fees on the quality of patient care, the work environment of health professionals, and the delivery of health services, few studies have provided concrete evidence regarding the impact of user–fee–removal policy on health care utilization and household expenditures in the LAC region [16-18].

Our study focuses on Jamaica, an upper–middle–income country in the LAC region. **Box 1** introduces Jamaica's health system. In May 2007, the Government of Jamaica implemented a new policy that removed user fees for all children aged 0–18 years in the public sector, except for the University Hospital of the West Indies (see **Box 2**). Our study aims to evaluate the impact of user–fee–removal on children's health care utilization and household health expenditure both on average and across income groups.

In our study, we tested three hypotheses: First, user–fee–removal will increase health care utilization among children, because it eliminates an important barrier to access health care. Second, user–fee–removal will reduce household health expenditures in families with sick children, especially for the poor households. Third, the immediate impact of the policy may vary between children from poor families and children from better–off families and could also be different in the medium– to long–term.

Earlier studies on the impact of user–fee–removal on health care utilization and household expenditures have been mostly limited to Africa [4–10,22]. Our study is in a country of Latin America and the Caribbean, with different characteristics from Africa: Most countries in LAC belong to upper–middle– or high–income country groups and are expanding universal health coverage, with substantial social segregation and inequalities in access to health care [23,24].

Methods used in earlier studies were largely constrained by data availability, and could not identify a causal relationship between user–fee–removal policy and the changes in health care utilization, as well as households' financial burden. We used interrupted time series (ITS) analysis to provide strong evidence for the policy's causal effects. By comparing the changes in outcomes right before and right after the policy change, ITS analysis assumes no changes in other factors that have a potential impact on the outcomes

Box 1. Background information on Jamaica's health system

Jamaica is an upper–middle–income country with a Gross Domestic Product (GDP) per capital of US$ 8467 (constant 2011 international PPP adjusted US$) and a total population of 2.7 million in 2014. In 2014, the unemployment rate of the total labor force was 13.2% [19].

Despite moderate improvements in life expectancy, infant mortality, and under–five mortality, Jamaica has not reached the MDG4 and MDG5 targets. Before the implementation of user–fee–removal policy in 2007, Jamaica's maternal mortality increased from 79 per 100 000 live births in 1990 to 91 per 100 000 live births in 2006. The under–5 mortality rate decreased by 36% from 30.6 per 1000 live births in 1990 to 19.5 in 2006. Infant mortality rate fell by 34% from 25.4 per 1000 live births in 1990 to 16.7 in 2006 [19].

Jamaica's health system is financed through a mix of public and private sources. The government spends around 6% of the GDP on health. Total health expenditure per capita in 2013 was US$ 512 (constant 2011 international PPP–adjusted US$). In 2013, the government expenditure accounted for 57% of the total health expenditure and out–of–pocket payments contributed 25%, while other private sources, such as private health insurance, accounted for 18% of the total [20].

Jamaica's public health sector is the primary provider of public health and hospital services and comprises approximately 5000 hospital beds across secondary and primary care facilities (around 1.8 hospital beds per capita). The private sector consists of approximately 200 beds (around 0.1 hospital beds per capita) and dominates ambulatory services and the provision of pharmaceuticals [20].

Box 2. Background information on Jamaica's user–fee–removal policy

Historically, Jamaica's political parties have used promise of better and lower cost health care services in campaigns to seek for votes. The removal of user fees between 2007 and 2008 in public health facilities was a practice of the campaign promise: When the People's National Party (PNP) was in government, it has introduced the no–user–fee policy for children aged 0–18 years and considered extending no–user–fees to adults. During the General Election in Jamaica in September, 2007, the Jamaica Labour Party (JLP) made the campaign promise to remove user fees for all patients in the public health sector. After the JLP party won the 2007 General Elections, the JLP administration fulfilled its campaign promise by removing user fees in the public health sector, except at the University Hospital of the West.

In Jamaica, adjustments to user fees is nothing new, as this practice dates back to the 1960s (**Table 5**). Over the past five decades, user fees have been abolished and/or altered eight times: In 1968, Jamaica's health authorities began revising its public health sector fee structure. User fees were removed in 1975 and reintroduced in 1984. After 23–years of user–fees in public health facilities, Jamaica abolished user fees in all public health facilities except for the University Hospital of the West Indies: on 28 May 2007, Jamaica removed user fee for children aged 0–18 years old, and on 1 April 2008, Jamaica removed user fees for adults.

that coincide with the policy of interest. Furthermore, ITS analysis can inform us the immediate, as well as its medium– to long–term impact of a policy.

Evaluating user–fee–removal policy for children has strong policy significance. Of all countries in the LAC region, Jamaica's progress in reaching the Millennium Development Goals (MDGs) target for reducing child and infant mortality has been among the slowest. Between 1990 and 2006, Jamaica's under–5 mortality rate declined by an annual rate of 2%, compared to 5% for countries in LAC and 4% in other upper–middle income countries in the world [19]. Given that child mortality is closely linked to access to health services [25,26], Jamaica's experience can provide evidence for countries aimed at applying user–fee removal to reduce child and infant mortality. We assessed the impact of user–fee–removal policy with an equity dimension, which is a prioritized by the Sustainable Development Goals (SDGs). Our findings would shed light for the other countries on how to achieve health equity in the SDG era.

METHODS

Data sources

This study uses data from the Jamaica Survey of Living Conditions (JSLC) – a nationally representative household survey, which consists of six core modules: demographic characteristics, household consumption, health, education, housing, and social protection. For this paper, we use data from 1996–2012. Health module data were not collected in 2003, 2005 and 2011 surveys, and thus these waves are excluded from the study. We totally used 14 rounds of surveys in this study. Some of the earlier waves are incomplete: for example, the education level of the household head, which is an important control variable in the regression analysis, has 26.9% missing values before 2004. To solve this problem, when conducting ITS analysis, we only presented the regression results using data from 2004–2012 in the main text to ensure the key variables are with high data quality. We provided the ITS regression results using data from 1996–2012 in Tables S2, S3 and S4 in **Online Supplementary Document**.

We excluded the observations interviewed within 4–weeks after the policy implementation date (28 May 2007), as it was not possible to identify whether their illness happened before or after the implementation of the policy. Moreover, subjects aged 18 years when the user fee exemption took place, were also excluded from analysis as it was difficult to ascertain whether they we over 18 or under 18 years by the time of policy change.

Outcome variables

We have two types of outcomes: (i) health care utilization and (ii) households' financial burden due to health care services. As with earlier studies, our measure of health care utilization is whether an individual sought care from a health professional if she/he experienced a health problem in the 4–weeks prior to the survey [27–29]. According to the JSLC, health professionals include doctors, nurses, pharmacists, midwives, healers, and other health professionals [30].

We define households' financial burden as out–of–pocket health expenditures as a share of the household's non–food consumption if the individual experienced a health problem in the 4–weeks prior to the survey [31]. Out–of–pocket health expenditure was defined as expenditures at public/private health centers, public/private hospitals, and costs of medicines purchased from public/private sources, which were not covered by insurance. Healthcare expenditure was considered to be catastrophic when the share of the household's out–of–pocket health expenditure was larger than 40% of the household's non–food consumption [22].

"People in poverty" was defined as those in the lowest wealth quintile. Utilization gap was defined as the difference in health professional visiting rates between children in poverty and children not in poverty. Gap in financial burden was defined as difference in the likelihood of encountering catastrophic health expenditure between patients from households in poverty and those not in poverty.

Statistical analysis

We used ITS analysis to assess the impact of user–fee–removal on health care utilization, financial burden, and equity. With a clear intervention time point, ITS regressions are able to identify both immediate and medium– to long–term changes in outcomes between the pre– and post–treatment segments, assuming that no other relevant changes that might impact outcomes coincide with the policy of interest. With this feature, ITS regressions enable examination of any significant changes after the introduction of a new policy.

Our data in 2007 is from May to September, covering the exact date when the policy was implemented on 28 May 2007. We can thus directly assess the changes in health care utilization and financial burden right before and right after the implementation of the user–fee–removal policy, but also analyze medium–to longer–term impact of the policy. The ITS model used in our analysis is represented as:

$$Y_{it} = \beta x_{it} + \alpha_1 trend_t + \alpha_2 post_t + \alpha_3 trend_t \times post_t + \varepsilon_{it}$$

where Y_{it} is the dependent variable for an individual observation, subscript i refers to the individual case and subscript t refers to the time, x_{it} are the individual–level and household–level variables at time t. $Trend_t$ is the time variable, indicating the number of years from 2000. For example, we use 4 to represent the year 2004. $Post_t$ is the time dummy for being in the post–treatment period, estimating the immediate change of outcome when the policy occurred. The interaction term, $trend_t \times post_t$, measures the change in trend in the post–intervention segment.

To further capture the policy's impact on the equity of health care utilization and household's financial burden, we stratify the analysis by children in poverty vs children not in poverty. Such stratification allows us to identify the effects of policy change on children from different wealth levels.

As health care utilization is a binary dependent variable, we use both ordinary least squares (OLS) and Logit regression for its analysis.

We conduct two robustness checks to ensure the results are not driven by unobservable confounders. In the first, we assume the removal of user fees in 2007 was targeted at adults over 18. If our estimates were driven by unobserved variables, such as changes in health system capacities, distance to the health facilities, opportunity cost of visiting health facilities, etc., it should also largely reflect on adults. The second robustness check assumes that the user–fee–removal policy was implemented in 28 May 2006, instead of 28 May 2007. This test could exclude the possibility that the results are driven by seasonal factors.

Role of the funding source

There was no funding source for this study. The corresponding author obtained access to the JSLC data of year 1996–2012 via the Derek Gordon Databank. The corresponding author had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis as well as the decision to submit for publication.

RESULTS

Table 1 summarizes the individual–level and household–level characteristics in 2004, 2006, 2008, 2010 and 2012. These characteristics remain stable over years. For example, the mean age of the respondents

Table 1. Description of key variables*

	2004	2006	2008	2010	2012
Individual's characteristics:					
Age	40.7	41.7	39.1	39.0	40.5
Male	37.0%	39.0%	39.0%	40.0%	41.0%
Respondent is the head of the household	42.0%	42.0%	43.0%	41.0%	43.0%
Covered by private or public health insurance	23.0%	21.0%	23.0%	19.0%	20.0%
Household's characteristics:					
Number of household members	4.2	4.2	4.2	4.0	4.0
Live in urban areas	24.0%	22.0%	31.0%	29.0%	23.0%
Live in rural areas	60.0%	59.0%	51.0%	52.0%	59.0%
Live in towns	16.0%	19.0%	19.0%	19.0%	18.0%
Education level of the household head:					
No education	3.0%	4.0%	2.0%	4.0%	2.0%
Primary education (Grade 1–6)	37.0%	32.0%	24.0%	27.0%	26.0%
Secondary education (Grade 7–13)	53.0%	57.0%	61.0%	58.0%	57.0%
Higher education (Grade 13+)	7.0%	7.0%	13.0%	11.0%	15.0%

*The education level of the household is obtained through the following approach: If the education level of the household head is available, we used it directly; if not available, we used the education level of the spouse of the household head instead; if still not available, we used the maximum education level of the household member instead; if still not available, we used the maximum education of the dwelling instead.

ranges from 39.0 to 41.7 years old; male accounts for 39% to 41% of the sample, average households' wealth quintiles range from 3.0 to 3.2.

Healthcare utilization

Figure 1 shows children's health care utilization over time, which largely increased from 54.2% before the implementation of user–fee–removal policy to 69.4% after the policy change in 2007. The rates remained high in the years from 2007 to 2012, ranging from 68.5% to 69.9%.

Figure 2 presents the utilization gap – the difference in health professional visiting rates between children in poverty and children not in poverty – with 95% confidence intervals (CI). Before the policy change in 2007, the utilization gap gradually rose from 2.6% to 16.4% between 1996 and 2006. In the short–term (2007–2008), the utilization gap further increased and reached 21.7% in 2008. However, this trend reversed in the medium– to long–term (after 2008) as the children in poverty increased their utilization at a higher rate than the children not in poverty. The utilization gap shrank by nearly two–thirds between 2008 and 2012, and reached 8.7% in 2012.

Table 2 presents the ITS regression results among individuals aged less than 18–years old (columns 1–3) and children aged less than 5 years old (columns 4–6). Column 1 and 4 shows the results for all children of that age group. Columns 2 and 3, as well as columns 5 and 6, stratify the children by wealth and show the regression results for children in poverty and children not in poverty respectively.

The implementation of user–fee–removal policy in 2007 immediately and significantly increased the odds of health care utilization by 97% (OR = 2.0, 95% CI 1.1 to 3.5, $P = 0.018$) among all children aged less

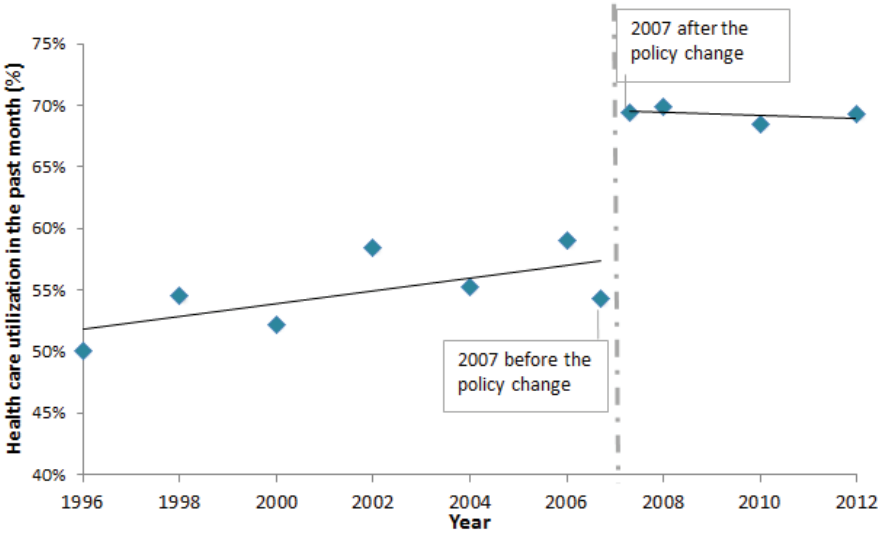

Figure 1. Healthcare utilization among under-18 children fell ill in the past 4 weeks. 1. To generate this figure, we split the 2007 sample into two parts–the sample interviewed before the implementation of user-fee-removal policy and the sample interviewed four weeks after it. 2. The observations numbers in the JSLC surveys vary by year (Most years have observation numbers between five thousand and eight thousand. For several years, the observation number is above fifteen thousand, such as 2008, and 2012). To increase the observation numbers involved in the generation of each data point in the figure above, we combined data from 1996 and 1997, 1998 and 1999, 2000 and 2001, 2001 and 2002, 2009 and 2010. 3. Sample weight is applied to all available years.

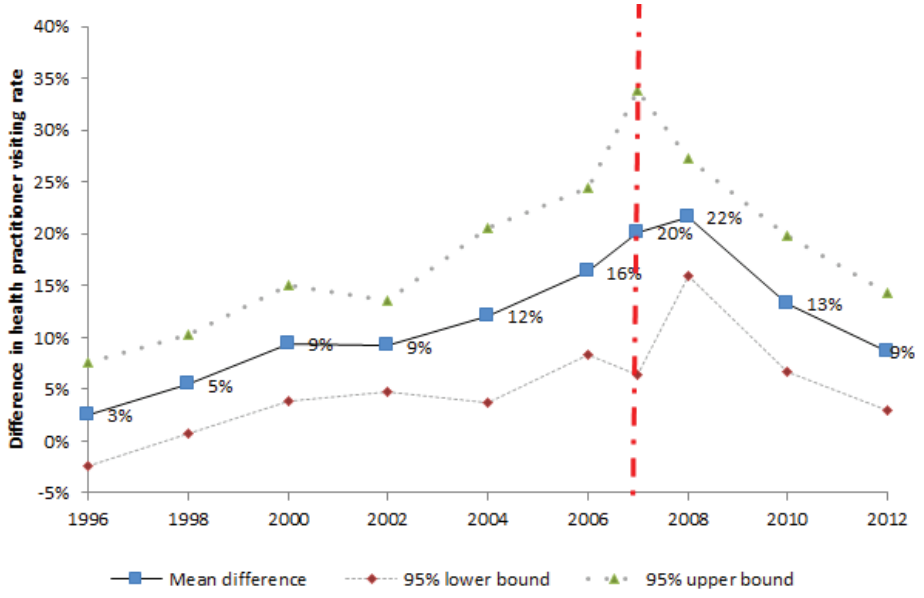

Figure 2. The difference in health care utilization between children in poverty and children not in poverty, among under-18 children fell ill in the past 4 weeks. 1. The observations numbers in the JSLC surveys vary by year (most years have observation numbers between five thousand and eight thousand. For several years, the observation number is above fifteen thousand, such as 2008, and 2012). To increase the observation numbers involved in the generation of each data point in the figure above, we combined data from 1996 and 1997, 1998 and 1999, 2000 and 2001, 2001 and 2002, 2009 and 2010. 2. Subjects under 18 years old in 2007 interviewed before 28 May 2007 are combined to year 2006 to prevent losing observations. 3. Sample weight is applied to all available years.

than 18 years. The stratified regressions show that children not in poverty significantly increased the odds of seeking for health care when fell ill by 82% (OR = 1.8, 95% CI 1.1 to 3.0, $P = 0.005$) following the policy change. There is no significant change to the health care utilization among children in poverty. A joint F–test in columns 2 and 3 rejected the null hypothesis that two models are the same (F = 135, $P < 0.001$).

Columns 4–6 are the results for children aged under 5 years. As shown in column 4, the odds of health care utilization increased by 354% (OR = 4.5, 95% CI 1.0 to 21.2, $P = 0.054$) after the policy change among all children aged less than 5 years. The stratified results in column 5 and 6 show that the magnitudes of "post" are large for both wealth groups, yet the effects are insignificant. A joint F–test on the results shown in columns 5 and 6 rejected the null hypothesis that two models are the same (F = 586, $P < 0.001$).

The results from the OLS regressions are very consistent with the OLS regression results (see Table S1 in **Online Supplementary Document**). These results are also consistent with the regression results with data from 1996 to 2012 (see Table S2 and S3 in **Online Supplementary Document).**

Healthcare expenditures

Figure 3 presents the percentage of households with sick children suffering from catastrophic health expenditure. We observe that the proportion of households with sick children suffering from catastrophic health expenditure immediately reduced from 3.1% to 2.0% after the policy change in 2007. The percentage of households with sick children suffering from catastrophic health expenditure continued to decline between 2007 and 2012. In 2012, only 0.6% of households with children aged less than 18–years encountered catastrophic health expenditure.

Figure 4 presents the financial burden gap, which is the difference between households in poverty and households not in poverty with sick children to encounter catastrophic health expenditures. The financial burden gap reduced rapidly in the short–term (2007–2008) and remained low in the medium– to long–term. In 2008, households in poverty, for the first time in the year analyzed, became no more likely to encounter catastrophic health expenditures than the households not in poverty. Such a phenomenon is also observed in years 2010 and 2012.

Table 2. ITS regression on the impact of user–fee–removal policy on health care utilization among children less than 18–years and children aged less than 5 years (Logit regression, presented in odds ratio and 95% CI)*

	Under 18 years old			Under 5 years old		
	(1)	(2)	(3)	(4)	(5)	(6)
	Overall (OR, 95% CI)	In poverty (OR, 95% CI)	Not in poverty (OR, 95% CI)	Overall (OR, 95% CI)	In poverty (OR, 95% CI)	Not in poverty (OR, 95% CI)
Trend	1.09 (1.00–1.18)†	0.9 (0.73–1.12)	1.13 (1.01–1.27)†	1.16 (0.95–1.42)	1 (0.67–1.48)	1.16 (0.96–1.42)
Post	1.97 (1.12–3.46)†	1.47 (0.23–9.45)	1.82 (1.10–3.00)†	4.54 (0.98–21.16)‡	7.17 (0.44–117.88)	2.93 (0.70–12.20)
Post×trend	0.95 (0.89–1.02)	1.08 (0.83–1.40)	0.94 (0.87–1.02)	0.85 (0.67–1.06)	0.87 (0.54–1.42)	0.88 (0.73–1.05)
Age	0.95 (0.94–0.97)§	0.98 (0.90–1.06)	0.95 (0.93–0.97)‡	0.84 (0.79–0.90)‡	0.84 (0.73–0.95)‡	0.84 (0.79–0.89)‡
Male	0.95 (0.82–1.09)	0.9 (0.52–1.55)	0.98 (0.79–1.21)	0.95 (0.74–1.23)	0.78 (0.39–1.57)	1.04 (0.78–1.39)
Enrolled in private health insurance	1.70 (1.18–2.44)§	1.45 (0.49–4.31)	1.82 (1.13–2.93)†	1.11 (0.76–1.62)	0.11 (0.02–0.56)‡	1.48 (0.81–2.69)
Enrolled in public health insurance	1.91 (0.83–4.43)	4.01 (1.71–9.44)‡	1.67 (0.63–4.46)	2.53 (0.98–6.52)‡	13.16 (3.77–45.93)‡	1.65 (0.50–5.45)
Wealth (the poorest wealth quintile is the reference group):						
Poorer	1.18 (0.90–1.55)			1.32 (0.75–2.33)		
Middle	1.55 (1.27–1.90)§			1.75 (1.10–2.78)†		
Richer	1.90 (1.34–2.69)§			2.11 (1.16–3.81)†		
Richest	1.72 (1.17–2.55)§			2.33 (1.10–4.96)†		
Household size, members only	0.97 (0.93–1.01)‡	0.95 (0.85–1.07)	0.95 (0.89–1.01)‡	0.97 (0.90–1.05)	0.96 (0.79–1.17)	0.95 (0.87–1.03)
Place of residence ("rural" is the reference group):						
Urban	1.18 (0.77–1.82)	1.01 (0.44–2.32)	1.29 (0.79–2.11)	1.11 (0.70–1.76)	1.4 (0.49–3.99)	1.14 (0.70–1.83)
Town	1.06 (0.65–1.71)	0.92 (0.50–1.70)	1.13 (0.72–1.78)	1.04 (0.58–1.87)	0.62 (0.18–2.12)	1.29 (0.75–2.21)
Education level of the head of the household ("no education" is the reference group)‖:						
Primary education (Grade 1–6)	0.61 (0.48–0.76)§	0.25 (0.14–0.45)§	1 (0.65–1.54)	0.55§ (0.40–0.76)	0.17 (0.07–0.42)§	1.19 (0.75–1.88)
Secondary education (Grade 7–13)	0.66 (0.45–0.97)§	0.34 (0.22–0.53)§	0.95 (0.51–1.75)	0.76 (0.51–1.12)	0.36 (0.19–0.70)§	1.12 (0.63–1.98)
Higher education (Grade 13+)	0.56 (0.36–0.89)†	0.44 (0.19–1.02)‡	0.76 (0.41–1.40)	0.67 (0.40–1.10)	0.42 (0.20–0.87)†	0.97 (0.51–1.84)
Cons.	1 (0.56–1.77)	5.78 (1.18–28.39)†	0.92 (0.48–1.74)	0.83 (0.19–3.57)	5.94 (0.42–84.18)	0.95 (0.23–3.87)
N	1931	441	1488	959	237	722

OR – odds ratio, CI – confidence interval

*The design of JSLC is a two–stage stratified random sampling design, with the first stage a selection of Primary Sampling Units (PSUs), and the second stage a selection of dwellings. Standard errors are clustered at sampling region level, which is one level above the PSUs. Two PSUs were grouped into one sampling region. The robust standard errors are reported in parentheses.

†Significance at the 1% level.

‡Significance at the 5% level.

§Significance at the 10% level.

‖ The education level of the household is obtained through the following approach: If the education level of the household head is available, we use it directly; if not available, we use the education level of the spouse of the household head instead; if still not available, we use the maximum education level of the household member instead.

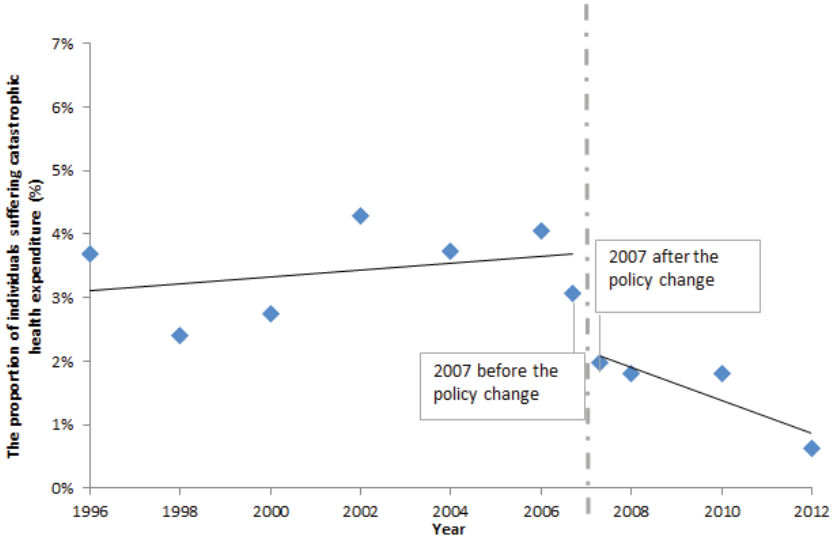

Figure 3. The proportion of households with under-18 children suffered catastrophic health expenditure in the 4 weeks preceding the survey if the children fell ill in the past 4 weeks. 1. To generate this figure, we split the 2007 sample into two parts–the sample interviewed before the implementation of user-fee-removal policy and the sample interviewed four weeks after it. 2. The observations numbers in the JSLC surveys vary by year (most years have observation numbers between five thousand and eight thousand. For several years, the observation number is above fifteen thousand, such as 2008, and 2012). To increase the observation numbers involved in the generation of each data point in the figure above, we combined data from 1996 and 1997, 1998 and 1999, 2000 and 2001, 2001 and 2002, 2009 and 2010. 3. Sample weight is applied to all available years.

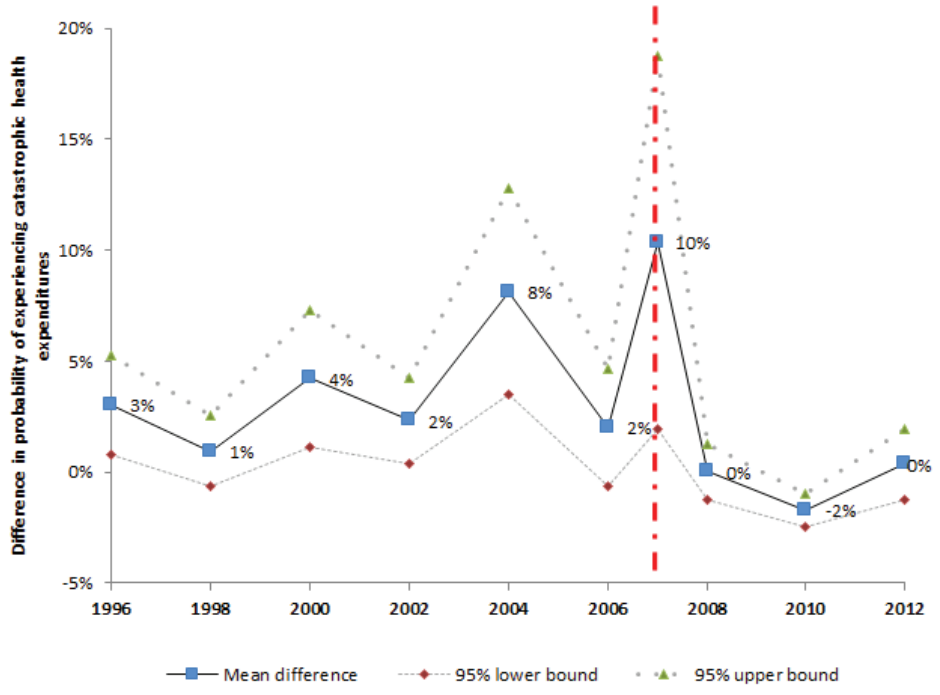

Figure 4. Difference in probability of experiencing catastrophic health expenditures between households in poverty and households not in poverty with sick children. 1. The observations numbers in the JSLC surveys vary by year (Most years have observation numbers between five thousand and eight thousand. For several years, the observation number is above fifteen thousand, such as 2008, and 2012). To increase the observation numbers involved in the generation of each data point in the figure above, we combined data from 1996 and 1997, 1998 and 1999, 2000 and 2001, 2001 and 2002, 2009 and 2010. 2. Subjects under 18 years old in 2007 interviewed before 28 May 2007 are combined to year 2006 to prevent losing observations. 3. Sample weight is applied to all available years.

Table 3 shows the ITS regression results on the household's financial burden. The first three columns cover children aged less than18–years and the last three columns refer to children aged less than 5 years. The results show that the user–fee–removal policy significantly reduced financial burden by 6.2 percentage points (95% CI –11 to –1, $P=0.02$) among children under 18–years. The stratified regressions show that the policy change reduced the financial burden significantly by 12.1 percentage points (95% CI –22 to –2, $P=0.02$) among children in poverty and 5 percentage points (95% CI –12 to 2, $P=0.133$) among children not in poverty.

Columns 4–6 are the results for children aged less than 5 years. As shown in column 4, the share of out–of–pocket health care expenditure in household's non–food consumption reduced by 7.1 percentage points (95% CI –15 to 1, $P=0.075$) after the policy change among all children aged less than 5 years. The stratified results in columns 5 and 6 show negative, yet insignificant magnitudes of "post". Joint F tests on the results shown in columns 2 and 3, as well as columns 4 and 5, rejected the null hypothesis that the models are the same ($F=194$, $P<0.001$; $F=167$, $P<0.001$). These results are consistent with the regression results using data from year 1996 to 2012 (see Table S4 in **Online Supplementary Document**).

Robustness check

To make sure that unobservable confounders do not drive our results, we conducted two robustness checks: First, we assume the removal of user fees in 2007 was targeted at adults aged more than 18–years. Table S5 in **Online Supplementary Document** presents the regression results of the test. As expected, we can see that the coefficients on "post" and "post×trend" are neither with large magnitudes nor statistically significant, indicating that the policy change in 2007 did not have any notable impact on the adults aged more than 18–years in terms of health care utilization and financial burden.

Table 3. ITS regressions on impact of user–fee–removal policy on out–of–pocket health care expenditure as a share of household's non–food consumption*

	Aged less than 18 years			Aged less than 5 years		
	1)	2)	3)	4)	5)	6)
	Overall	In poverty	Not in poverty	Overall	In poverty	Not in poverty
Trend	–0.003 (0.004)	–0.007 (0.007)	–0.002 (0.006)	–0.001 (0.007)	0.001 (0.015)	0 (0.008)
Level change after user–fee–removal policy (post)	–0.062 (0.023)†	–0.121 (0.045)†	–0.051 (0.031)	–0.071 (0.036)‡	–0.091 (0.085)	–0.057 (0.040)
Trend change after user–fee–removal policy:						
(Post×trend)	0.006 (0.004)	0.013 (0.011)	0.004 (0.006)	0.005 (0.007)	0.008 (0.015)	0.002 (0.008)
Age	–0.001 (<0.001)§	0.000 (0.001)	–0.001 (<0.001)§	–0.003 (0.001)†	–0.004 (0.002)‡	–0.003 (0.001)†
Male	–0.004 (0.003)	–0.006 (0.009)	–0.004 (0.003)	–0.006 (0.007)	–0.001 (0.016)	–0.008 (0.008)
Head of the household	0.015 (0.066)	–0.073 (0.034)‡	0.100 (0.008)§			
Enrolled in private health insurance	–0.011 (0.006)‡	0.032 (0.026)	–0.021 (0.006)§	–0.017 (0.009)‡	–0.025 (0.010)†	–0.022 (0.009)†
Enrolled in public health insurance	–0.011 (0.008)	–0.015 (0.008)†	–0.014 (0.011)	–0.007 (0.011)	–0.005 (0.014)	–0.015 (0.014)
Wealth (the poorest wealth quintile is the reference group)†:						
Poorer	0.003 (0.004)			0.004 (0.005)		
Middle	0.008 (0.004)‡			0.01 (0.007)		
Richer	0.004			0.003		
	(0.009)			(0.012)		
Richest	–0.008			–0.009		
	(0.006)			(0.006)		
Household size, members only	–0.006 (0.001)§	–0.002 (0.002)	–0.007 (0.001)§	–0.006§ (0.001)	–0.002 (0.002)	–0.008 (0.002)§
Place of residence ("rural" is the reference group):						
Urban	–0.005 (0.004)	–0.015 (0.012)	–0.003 (0.004)	–0.007 (0.005)	–0.016 (0.020)	–0.006 (0.004)
Town	–0.007 (0.002)§	–0.004 (0.004)	–0.008 (0.003)§	–0.004 (0.003)	0.005 (0.007)	–0.008 (0.003)†
Education level of the head of the household ("no education" is the reference group)‖:						
Primary education (Grade 1–6)	–0.005 (0.006)	–0.023 (0.014)	0.000 (0.008)	–0.01 (0.013)	–0.045 (0.020)†	0.006 (0.009)
Secondary education (Grade 7–13)	–0.010 (0.004)†	–0.021 (0.011)‡	–0.007 (0.007)	–0.009 (0.005)	–0.024 (0.015)	–0.005 (0.009)
Higher education (Grade 13+)	–0.008 (0.004)‡	0.006 (0.012)	–0.013 (0.008)	–0.008 (0.006)	–0.011 (0.015)	–0.009 (0.009)
cons	0.128 (0.022)§	0.133† (0.056)	0.132 (0.034)§	0.132§ (0.040)	0.099 (0.085)	0.135 (0.049)†
r^2¶	0.076	0.062	0.1	0.094	0.076	0.132
N	1921	439	1482	951	234	717

*The design of JSLC is a two–stage stratified random sampling design, with the first stage a selection of Primary Sampling Units (PSUs), and the second stage a selection of dwellings. Standard errors are clustered at sampling region level, which is one level above the PSUs. Two PSUs were grouped into one sampling region. The robust standard errors are reported in parentheses. We excluded the top 1% of individuals with the highest health care cost (outliers).
†Represents significance at the 5% level.
‡Represents significance at the 10% level.
§Represents significance at the 1% level.
‖ The education level of the household is obtained through the following approach: If the education level of the household head is available, we use it directly; if not available, we use the education level of the spouse of the household head instead; if still not available, we use the maximum education level of the household member instead; if still not available, we use the maximum education of the dwelling instead.
¶r^2 represents the adjusted R square.

Second, we assume the user–fee–removal policy was implemented on 28 May 2006, instead of 28 May 2007. Tables S6, S7 and S8 in **Online Supplementary Document** presents the results of using the alternative starting date. None of the coefficients on "post" and "post*trend" are with large magnitudes or statistically significant, suggesting the robustness of our findings.

DISCUSSION

Figure 1 shows that the implementation of user–fee–removal policy in Jamaica led to increased children's health care utilization immediately after the introduction of the policy and the utilization remained high in the medium– to long–term. This finding is consistent with earlier studies elsewhere that elimination of user fees could effectively promote utilization because it removes financial barrier to access health care [1–10].

The OLS regressions in Table S1 in **Online Supplementary Document** suggest that health care utilization increased by 15.8 percentage points among children aged less than 18–years and 32.5 percentage points among children aged less than 5 years. In fact, a large proportion of children's deaths are preventable and curable, for example, the 2005 MICS survey showed that 35% of Jamaican girls and 60% of the Jamaican boys with suspected pneumonia were not treated with potentially life–saving antibiotics [32]. Better health care access is an essential factor to save these lives [33].

Figure 2, combined with the ITS results in **Table 2**, implies that the short–term and the medium– to long–term results appear to have different equity impact: In the short–term (2007–2008), the utilization gap enlarged due to the faster increase in health care utilization among children not in poverty compared to children in poverty. One potential explanation for this observation is that wealthier households are better at receiving information about new policies and tend to be quicker in changing their behavior in the short–term. While in the medium– to long–term (after 2008), **Figure 2** further indicates that the utilization gap decreased rapidly as the utilization by children in poverty increased at a faster pace than non–poor between 2008 and 2012. This finding suggests that while conducting equity analysis, one should pay special attention to the study period, because various lengths of studies could produce different results.

We find that the user–fee–removal policy significantly reduced the share of out–of–pocket health care expenditure in households' non–food consumption by 6.2 percentage points among children aged less than 18–years and 7.1 percentage points among children aged less than 5 years. The children in poverty appear to benefit more than the children not in poverty, which indicates that the policy had a larger effect to relieve the financial burden of the poor. Our results are consistent with earlier studies undertaken elsewhere, demonstrating that user–fee exemptions reduce part of financial barriers for patients, and help improve access to health services [34–37].

The study has four potential limitations. First, we cannot conclusively determine whether the increase in health care utilization was due to the release of unmet demand or moral hazard. When health services become free or inexpensive, people may tend to overuse them, leading to wastage of health resources. Whether this happened in the case of Jamaica and the extent to which it changed people's behavior is unclear. Second, due to the limited sample size, we are not able to conduct an analysis on the health care utilization among infants and can neither draw any conclusion on the link between the policy change and health outcomes. If more comprehensive data with larger sample size were available, more detailed analysis would be possible. Third, health care expenditure data are not collected yearly, but with a 4–week recall period. We adjusted the yearly non–food consumption to reflect the 4–week period. This method may generate biased estimates if the non–food consumption is not evenly divided over months or if children are more or less likely to be sick in the months the surveys were conducted. Fourth, although two sets of robustness checks were conducted, this study is still observational and could not completely rule out the possibility of confounders.

Notwithstanding these limitations, however, our results are in line with earlier studies undertaken elsewhere and strongly confirm the effectiveness of user–fee–removal policies in improving the equal access to health care for children by promoting the equitable utilization of health services and reducing the financial burden which households may confront [1–10]. An important implication of our results is that removing user fees is feasible and should be considered as part of a potential strategy to achieve UHC. Our results also suggest that the effects of policies may change over time. Hence, policymakers should take both short–term and the long–term effects into consideration when designing user–fee policies.

Table 5. User fees changes in Jamaica, 1968–2008 [21]

Details	Year	In government (JLP or PNP)
Revised user fees	1968	JLP
Removal of user fees	1975	PNP
Re–introduction of user fees	1984	JLP
Adjustment of user fees (upwards)	1993	PNP
Adjustment of user fees (upwards)	1999	PNP
Adjustment of user fees (upwards)	2005	PNP
Removal of user fees (children aged 0–18 years old)	May 2007	PNP
Removal of user fees – all public patients	April 2008 – Present	JLP

JPL – Jamaica Labour Party, PNP – People's National Party

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Competing interests: The authors have completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available upon request from the corresponding author), and declare no conflict of interest.

REFERENCES

1 Lagarde M, Palmer N. The impact of user fees on access to health services in low-and middle-income countries. Cochrane Database Syst Rev. 2011;(4):CD009094. Medline:21491414

2 Yates R. Universal health care and the removal of user fees. Lancet. 2009;373:2078-81. Medline:19362359 doi:10.1016/S0140-6736(09)60258-0

3 John EU. The impacts of user fees on health services in sub-Saharan African countries: a criticical analysis of the evidence. Am J Public Health Res. 2013;1:196-202. doi:10.12691/ajphr-1-8-1

4 Nabyonga J, Desmet M, Karamagi H, Kadama PY, Omaswa FG, Walker O. Abolition of cost-sharing is pro-poor: evidence from Uganda. Health Policy Plan. 2005;20:100-8. Medline:15746218 doi:10.1093/heapol/czi012

5 Pariyo GW, Ekirapa-Kiracho E, Okui O, Rahman MH, Peterson S, Bishai DM, et al. Changes in utilization of health services among poor and rural residents in Uganda: are reforms benefitting the poor? Int J Equity Health. 2009;8:39. Medline:19909514 doi:10.1186/1475-9276-8-39

6 Burnham GM, Pariyo G, Galiwango E, Wabwire-Mangen F. Discontinuation of cost sharing in Uganda. Bull World Health Organ. 2004;82:187-95. Medline:15112007

7 Masiye F, Chitah BM, McIntyre D. From targeted exemptions to user fee abolition in health care: experience from rural Zambia. Soc Sci Med. 2010;71:743-50. Medline:20542363 doi:10.1016/j.socscimed.2010.04.029

8 Xu K, Evans DB, Kadama P, Nabyonga J, Ogwal PO, Nabukhonzo P, et al. Understanding the impact of eliminating user fees: utilization and catastrophic health expenditures in Uganda. Soc Sci Med. 2006;62:866-76. Medline:16139936 doi:10.1016/j.socscimed.2005.07.004

9 Ridde V, Haddad S, Heinmüller R. Improving equity by removing healthcare fees for children in Burkina Faso. J Epidemiol Community Health. J Epidemiol Community Health. 2013;67:751-7. Medline:23776054 doi:10.1136/jech-2012-202080

10 Nabyonga Orem JN, Mugisha F, Kirunga C, Macq J, Criel B. Abolition of user fees: the Uganda paradox. Health Policy Plan. 2011;26 Suppl 2:ii41-51. Medline:22027918 doi:10.1093/heapol/czr065

11 Gordon-Strachan G, Bailey W, Henry-Lee A, Barnett J, Lalta S, Alleyne D. The impact of user fees for preventive health care—Jamaica. Soc Econ Stud. 2010;59:123-52.

12 World Health Organization. World Health Assembly. Available: http://www.who.int/mediacentre/events/governance/wha/en/. Accessed: 14 March 2017.

13 McPake B, Brikci N, Cometto G, Schmidt A, Araujo E. Removing user fees: learning from international experience to support the process. Health Policy Plan. 2011;26 Suppl 2:ii104-117. Medline:22027915 doi:10.1093/heapol/czr064

14 International Labour Office. World Labour Report 2000: Income security and social protection in a changing world. 2000. Available: http://www.ilo.org/public/english/standards/relm/gb/docs/gb279/pdf/esp-7.pdf. Accessed: 13 January 2017.

15 Institute TCPR. Fee or free a survey? A survey of the no-user fee policy in public hospitals in Jamaica. 2013. Available: http://www.capricaribbean.com/documents/no-user-fee-policy-public-hospitals-jamaica. Accessed: 11 November 2015.

16 De La Haye W, Alexis S. The impact of a no-user-fee policy on the quality of patient care/service delivery in Jamaica. West Indian Med J. 2012;61:168-73. Medline:23155965

17 Bratt JH, Weaver MA, Foreit J, De Vargas T, Janowitz B. The impact of price changes on demand for family planning and reproductive health services in Ecuador. Health Policy Plan. 2002;17:281-7. Medline:12135994 doi:10.1093/heapol/17.3.281

18 Campbell A. The abolition of user fees in the Jamaican public health system: impact on access, care provided and the work of the professional nurse [thesis]. Wellington: Victoria University of Wellington; 2013.

19 World Bank. Indicators. Available: http://data.worldbank.org/indicator. Accessed: 12 July 2016.

20 Chao S. Jamaica's effort in improving universal access within fiscal constraints. 2013. Available: http://documents.worldbank.org/curated/en/408381468044133381/Jamaicas-effort-in-improving-universal-access-within-fiscal-constraints/. Accessed: 12 July 2016.

21 Coombs M. Universal Coverage in Jamaica. 2013. Available: http://www2.paho.org/hq/index.php?option=com_docman&task=doc_view&gid=19100&Itemid=270. Accessed: 4 May 2017.

22 World Health Organization. Designing health financing systems to reduce catastrophic health expenditure. 2005. Available: http://www.who.int/health_financing/pb_2.pdf. Accessed:13 January 2017.

23 Atun R, De Andrade LOM, Almeida G, Cotlear D, Dmytraczenko T, Frenz P, et al. Health-system reform and universal health coverage in Latin America. Lancet. 2015;385:1230-47. Medline:25458725 doi:10.1016/S0140-6736(14)61646-9

24 Cotlear D, Gómez-Dantés O, Knaul F, Atun R, Barreto IC, Cetrángolo O, et al. Overcoming social segregation in health care in Latin America. Lancet. 2015;385:1248-59. Medline:25458715 doi:10.1016/S0140-6736(14)61647-0

25 James C, Morris SS, Keith R, Taylor A. Impact on child mortality of removing user fees: simulation model. BMJ. 2005;331:747-9. Medline:16195292 doi:10.1136/bmj.331.7519.747

26 Rutherford ME, Mulholland K, Hill PC. How access to health care relates to under-five mortality in sub-Saharan Africa: systematic review. Trop Med Int Health. 2010;15:508-19. Medline:20345556 doi:10.1111/j.1365-3156.2010.02497.x

27 Almeida G, Sarti FM. Measuring evolution of income-related inequalities in health and health care utilization in selected Latin American and Caribbean countries. Rev Panam Salud Publica. 2013;33:83-9. Medline:23525337 doi:10.1590/S1020-49892013000200002

28 Evans D, Hausladen S, Kosec K, Reese N. Community-based conditional cash transfers in Tanzania: results from a randomized trial. 2014. Available: https://openknowledge.worldbank.org/handle/10986/17220. Accessed. 13 January 2017.

29 Levesque J-F, Harris MF, Russell G. Patient-centred access to health care: conceptualising access at the interface of health systems and populations. Int J Equity Health. 2013;12:18. Medline:23496984 doi:10.1186/1475-9276-12-18

30 Planning Institute of Jamaica. Jamaica Survey of Living Conditions. Kingston: PIOJ & STATIN: 2013.

31 Su TT, Kouyaté B, Flessa S. Catastrophic household expenditure for health care in a low-income society: a study from Nouna District, Burkina Faso. Bull World Health Organ. 2006;84:21-7. Medline:16501711 doi:10.2471/BLT.05.023739

32 Jamaica Ministry of Health. Child and maternal health in Jamaica. 2011. Available: http://www.commonwealthhealth.org/americas/jamaica/child_and_maternal_health_in_jamaica/. Accessed: 27 March 2016.

33 Rudan I, El Arifeen S, Bhutta ZA, Black RE, Brooks A, Chan KY, et al. Setting research priorities to reduce global mortality from childhood pneumonia by 2015. PLoS Med. 2011;8:e1001099. Medline:21980266 doi:10.1371/journal.pmed.1001099

34 Mwabu G, Mwanzia J, Liambila W. User charges in government health facilities in Kenya: effect on attendance and revenue. Health Policy Plan. 1995;10:164-70. Medline:10143454 doi:10.1093/heapol/10.2.164

35 Meuwissen LE. Problems of cost recovery implementation in district health care: a case study from Niger. Health Policy Plan. 2002;17:304-13. Medline:12135997 doi:10.1093/heapol/17.3.304

36 Pradhan M, Prescott N. Social risk management options for medical care in Indonesia. Health Econ. 2002;11:431-46. Medline:12112492 doi:10.1002/hec.689

37 Wagstaff A, Doorslaer EV. Catastrophe and impoverishment in paying for health care: with applications to Vietnam 1993-1998. Health Econ. 2003;12:921-34. Medline:14601155 doi:10.1002/hec.776

38 Deininger K, Mpuga P. Economic and welfare impact of the abolition of health user fees: evidence from Uganda. J Afr Econ. 2005;14:55-91. doi:10.1093/jae/ejh034

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PAPERS

Sociodemographic, behavioral, and environmental factors of child mortality in Eastern Region of Cameroon: results from a social autopsy study

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Background While most child deaths are caused by highly preventable and treatable diseases such as pneumonia, diarrhea, and malaria, several sociodemographic, cultural and health system factors work against children surviving from these diseases.

Methods A retrospective verbal/social autopsy survey was conducted in 2012 to measure the biological causes and social determinants of under–five years old deaths from 2007 to 2010 in Doume, Nguelemendouka, and Abong–Mbang health districts in the Eastern Region of Cameroon. The present study sought to identify important sociodemographic and household characteristics of the 1–59 month old deaths, including the coverage of key preventive indicators of normal child care, and illness recognition and care–seeking for the children along the Pathway to Survival model.

Findings Of the 635 deceased children with a completed interview, just 26.8% and 11.2% lived in households with an improved source of drinking water and sanitation, respectively. Almost all of the households (96.1%) used firewood for cooking, and 79.2% (n = 187) of the 236 mothers who cooked inside their home usually had their children beside them when they cooked. When 614 of the children became fatally ill, the majority (83.7%) of caregivers sought or tried to seek formal health care, but with a median delay of 2 days from illness onset to the decision to seek formal care. As a result, many (n = 111) children were taken for care only after their illness progressed from mild or moderate to severe. The main barriers to accessing the formal health system were the expenses for transportation, health care and other related costs.

Conclusions The most common social factors that contributed to the deaths of 1–59–month old children in the study setting included poor living conditions, prevailing customs that led to exposure to indoor smoke, and health–related behaviors such as delaying the decision to seek care. Increasing caregivers' ability to recognize the danger signs of childhood illnesses and to facilitate timely and appropriate health care–seeking, and improving standards of living such that parents or caregivers can overcome the economic obstacles, are measures that could make a difference in the survival of the ill children in the study area.

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The United Nations recently released its 2015 report that found that the global under–five mortality rate has more than halved since 1990 [1]. This encouraging progress may be attributable to at least the two MDGs dedicated to maternal, reproductive, and child health, namely goal four (MDG 4) that aimed to reduce child mortality by two–thirds and goal five (MDG 5) to reduce the maternal mortality ratio by 75% [2].

However, some critics posit that the MDGs failed to address some gaps that need to be tackled in the new universal and transformative post–2015 development agenda. For example, there are persistent disparities in the under–5 mortality rates within countries, which render any country–level MDGs assessment of progress or achievement misleading or less meaningful.

Child survival is described as being more sensitive to the effects of poverty or material deprivation than most other health outcomes [3]. Poor households are more likely to be exposed to diseases, often lack access to safe water and sanitation, cannot afford nutritious diets, and often have no access to good–quality or affordable health care. In Mozambique, Macassa and Burstrom [4] concluded that behavioral and cultural factors also contribute to child mortality. There is extensive literature on the role of poor access to timely and quality health care interventions on child survival [5–7].

In Cameroon, it is estimated that the upward trend in the under–five mortality rate during the 1990s, from 138 deaths per 1000 live births to 150 deaths per 1000, has now reversed, with the rate having decreased to 88 deaths per 1000 in 2015 [1]. Yet, important disparities remain, with the Eastern region of the country experiencing the second highest under–five mortality at 187 deaths per 1000 live births [8].

There has been a recent call from the international community for Cameroon to accelerate the pace of its progress in order to achieve an under–five mortality rate of 25 or fewer deaths per 1000 live births by 2030 [1]. To reach that goal, an understanding of the most important biological causes of child deaths, along with the behavioral and contextual factors that affect child survival, could help Cameroon make appropriate choices for its situation and accelerate the achievement of improved child survival outcomes.

The present manuscript is part of a series drawn from the WHO/UNICEF–supported Child Health Epidemiology Reference Group's (CHERG) effort to directly measure the causes and determinants of neonatal and child mortality in selected, high–mortality countries such as Cameroon. This paper focuses on the social autopsy (SA) data of the deaths of children 1–59 months of age that occurred from 2007 to 2010 in Doume, Nguelemendouka, and Abong–Mbang districts in the Eastern region of Cameroon.

From a policy perspective, the purpose of this study was to unveil some of the complex and modifiable factors that contribute to child mortality [9] in the study area, known as one of the most impoverished regions of Cameroon [10], that led to its being dubbed "the forgotten region", for use by health managers to prioritize and design evidence–based child survival interventions.

METHODS

The fundamental aim of the study was to identify the household, community, and health system factors that contributed to the child deaths that occurred from 2007 to 2010 in Doume, Nguelemendouka, and Abong–Mbang districts of Cameroon.

Information on births and deaths came from the complete birth histories recorded for all interviewed mothers in a baseline census of all a 16954 households in the three districts undertaken by Population Services International (PSI) from October to December 2010 for a Home–Based Management of Malaria project.

The sampling methodology of the verbal/social autopsy (VASA) study has been fully described elsewhere [11]. In brief, the study universe included 930 deaths of young children (1–59 months of age) from 2007 to 2010 identified by the census birth histories conducted in the last quarter of 2010. The sampling strategy was to minimize the recall period by taking the one most recent under–five years old death in each household with at least one such death in the four years prior to the census, moving back in time over the survey period until the desired sample size of deaths of 660 child deaths was achieved.

The description of the data collection tools and the fieldwork is available in a paper published earlier [11]. The VASA questionnaire chronologically blended the Population Health Metrics Research Consortium (PHMRC) verbal autopsy questionnaire to determine the biomedical cause of death, with the CHERG Pathway Analysis SA questionnaire [12] to inquire about well–child and illness events leading up to a

death. The VASA questionnaire was developed in English and, for the study in Cameroon was translated to French, which is understood by the majority of persons in the study area. Only the local terms for key questionnaire items, such as illness signs and symptoms and the names of local traditional and formal health care providers, were phonetically transliterated to six major local languages– Mongo–Ewondo, Maka, Baka, Mpoong moon, Onveng and Abakoum. The translations were then inserted into a CSProX software application (Serpro S.A, Santiago, Chile) that was developed to enable direct, field–based Computer Aided Personal Interview (CAPI) capture of the VASA interview data on a netbook computer.

For the fieldwork, twenty female interviewers who were native speakers of the local languages and had at least a high school education, received 10 days of in–classroom training in the VASA study background, procedures, ethical standards and conduct of the interview on the netbook, followed by 3 days of field practice, all conducted in French and the local languages. The interviewers were split into three groups (one per district) based on their knowledge of the districts and local languages, and their prior involvement during the mortality survey conducted by PSI in 2010. Each team was led by one field supervisor from the National Statistics Institute (NIS) and in addition received two field visits by office supervisors during the forty days of data collection. The interviewers were trained to select as the respondent the person most knowledgeable of the child's fatal illness and care provided to the child for the illness. The interview covered the fatal illness from onset to death, including for neonatal deaths, the mother's pregnancy and delivery. Hence, additional eligible respondents were permitted if necessary. In cases with discordant responses among respondents, the main respondent's answers were considered. Data collection occurred from 5 March to 15 April 2012.

The analysis of data on preventive and curative care followed the same procedures as described in a prior paper [13], and was guided by the following: (a) review of several sociodemographic and household determinants of the deceased children; (b) coverage of key interventions along the continuum of normal child care provided both inside and outside the home; and (c) illness recognition and care–seeking patterns encompassed by the Pathway to Survival model [9,12,14]. All the examined interventions have been shown to be efficacious and effective in promoting child survival and thus are included among the interventions examined by the Lives Saved (LiST) tool [12] or recommended by the World Health Organization (WHO), and so should be accessible to all children. The list and definitions of some operational variables used throughout this paper are provided in Koffi et al. [13].

In addition, a scoring system was developed based on caregivers' reports of the child's feeding behavior, activity level and mental status in order to assess the impact of perceived illness severity at illness onset on caregivers' attempts at care–seeking for their child's illness. Hence, three independent categories of illness severity were constructed: normal/mild, moderate, and severe. Details of the method were provided in a prior paper [11]. The Cronbach's alpha coefficients [15] of the summated scores showed values of 0.90 at the onset of the fatal illness and when the decision to seek care was made. This suggested that the items in the scores elicited highly consistent responses, justifying the reliability of the summated scores according to Nunnaly criteria [16].

Separate to that scoring system, we derived a symptom severity scoring system based on the caregivers observed symptoms by using the World Health organizations' (WHO) Integrated Management of Childhood Illnesses (IMCI) severity grading for the first symptoms as observed. For the illness symptoms that were in the VA instrument but not in the IMCI, two physician authors (HDK, AKK) assigned symptoms as severe (requiring referral to higher level formal care) or possibly severe (requiring formal health care). The listing of the symptoms and their severity scoring are given in **Online Supplementary Document.**

The VASA study in Cameroon was first approved by the Cameroon National Research Committee, then by the Johns Hopkins School of Public Health's Institutional Review Board. All respondents provided informed consent before the interview was conducted.

RESULTS

Interviews were completed for 635 (96.2%) of the 660 child (1–59 months of age) deaths included in the study sample. More than two–thirds of the respondents (74.7%) were mothers, while 10.6% were fathers of the deceased children, 8.7% grand–mothers, and 6% others relatives.

The sociodemographic characteristics of the deceased children are presented in **Table 1**. The median age at illness onset was 12 months (interquartile range IQR:7–24 months), with two–thirds of the deaths occurring either in the post–neonatal (1–11 months of age) period (41.1%) or second–year (26.3%) of life.

Table 1. Characteristics of 635 deceased children

Characteristics	N*	Percentage
Median age at illness onset (in months)	12 (IQR: 7–24)	
Median illness duration (in days)	7 (IQR: 3–14)	
Median age at death (in months):	12 (IQR: 8–24)	
1–11	261	41.1
12–23	167	26.3
24–59	205	32.4
Don't know	1	0.2
Sex:		
Male	311	49.0
Female	324	51.0
Masculinity ratio	96	
Place of birth:		
Hospital	117	18.4
Other health provider or facility	74	11.7
On route to a health provider or facility	3	0.5
Home	437	68.8
Other	4	0.6
Place of death:		
Hospital	137	21.6
Other health provider or facility	45	7.1
En route to a health provider or facility	20	3.2
Home	368	58.0
Other	65	10.2

IQR – interquartile range

*Q1–Q3: First and third quartiles of the interquartile range (IQR).

Median illness duration was 7 days. There were slightly more deaths of females than males, with a male ratio of 96.0. Most (68.8%) of the 635 deceased children were born at home; the majority (58.0%) also died at home.

Table 2 shows the characteristics of the mother, her domestic partner, and the household. Approximately 80% of the mothers were married or living with a man at the time of the interview; two–thirds (67.7%) entered in union before 20 years of age. About a third of the mothers (29.3%) lost their index child before reaching 20 years of age. More than two–thirds (71.2%) had some primary level of education (1–6 years of schooling). The average household size was 7.4 persons. The occupation most cited for the breadwinner was farmer/agricultural worker (68.3%). About a quarter or less of the households had modern facilities such as electricity, an improved source of drinking water, and sanitation (flush or improved pit toilet). The vast majority (96.1%) of the households used firewood as fuel for cooking. The median travel time to the caregiver's usual health care center was 30.0 minutes. The median time families had been living continuously in the same community was about 10 years.

Figure 1 presents a summary of the nutritional intake before the illness began of the 446 children whose fatal illnesses started between 0–23 months of age. Overall, just 36.3% (n = 162) were being appropriately fed for their age (see **Figure 1**). In more detail, only 15.5% (n = 18) of the 116 children whose fatal illnesses began

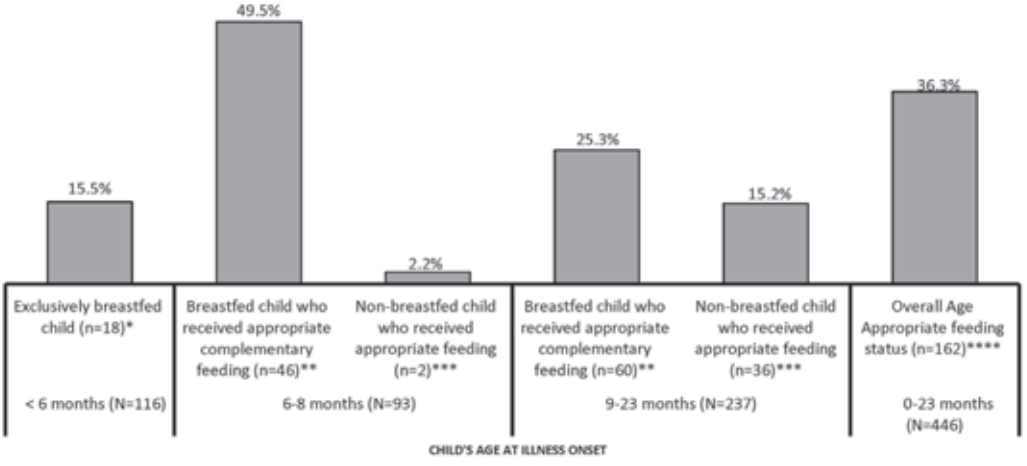


Figure 1. Appropriate feeding for children whose illness started at age 0–23 months. *Child' illness began before 6 months of age (1-5 months), he/she was being breastfed at the time of fatal illness and was not given anything but breast milk as food. **Breastfed children whose fatal illness started at 6-8 months old and 9-23 months old, and received, respectively, at least two and three complementary non-liquid feedings each day. ***Never-breastfed children whose fatal illness started at 6-8 months old and 9-23 months old, respectively, and received at least four replacement feeds each day (including milk and solid, semi-solid and soft foods). ****Children whose fatal illness started at 0-23 months and satisfied one of the above conditions.

at 0–5 months of age were exclusively breastfed. Among the 330 children whose illness began at 6–23 months of age, only 32.1% (n = 106) of breastfed children received the recommended complementary non–liquid feeds each day, while 11.5% (n = 38) of non–breastfed children received at least four replacement feeds each day.

Figure 2 shows some preventive home care received by the 1–59 months old children along the continuum of care. About one in five children (20.8%) were likely not to be exposed to smoke, ie, he/she was usually away from the mother when she cooked inside the house. Less than half (46.5%) of the children always slept under an insecticide–treated bed net before their fatal illness began.

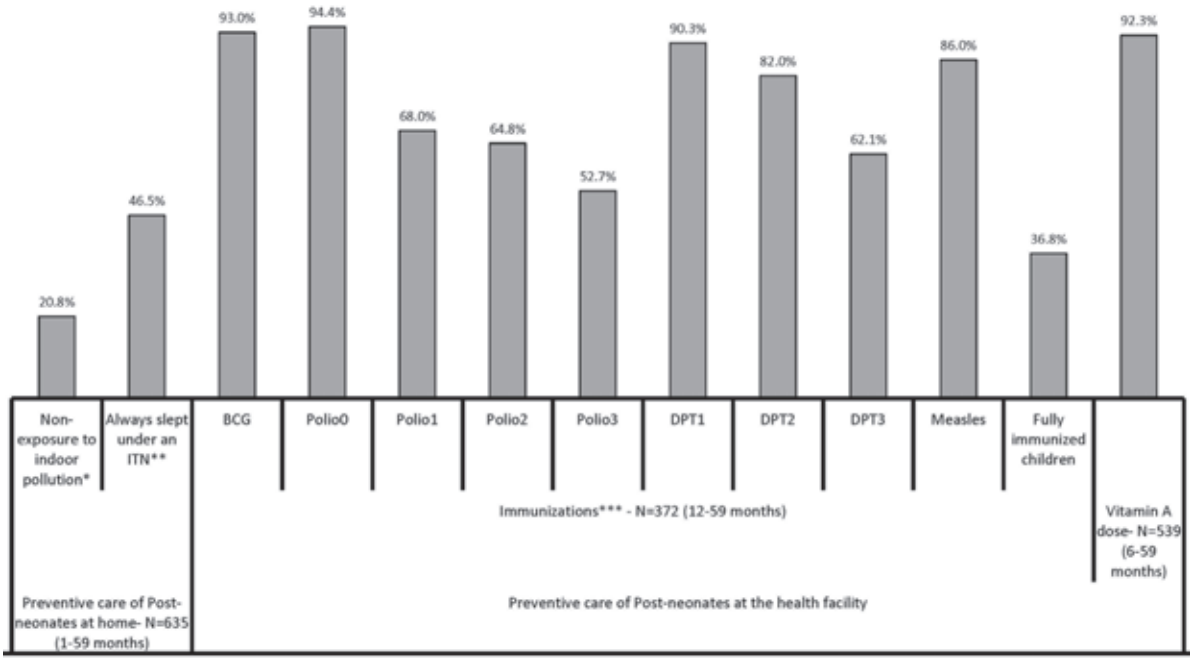


Figure 2. Coverage along the continuum of care for 1-59-month old child deaths in Doume, Nguelemendouka and Abong-Mbang districts, in Eastern Region of Cameroon, from 2007-2010. *Proportion of children who were NOT usually beside or carried by their mother when she cooked inside the home. **Insecticide-treated bed net. ***Information on immunizations was obtained either from the vaccination card or when there was no written record, from the respondent (mainly the mother). Polio0 is the Polio vaccination given at birth; Fully Immunized children received BCG, measles, and three doses each of DPT and polio vaccine (excluding polio vaccine given at birth).

Table 2. Characteristics of the mother and her household, 635 child deaths

Maternal characteristics	n	Percentage
Married or living with a man	509	80.2
Median age when first married (years):	18 (IQR: 15–20)	
12–15	131	25.7
16–19	214	42.0
20–44	152	29.9
Don't know	12	2.4
Mother's median age at time of child death (in years):	24 (IQR: 19–31)	
13–16	56	8.8
17–19	111	17.5
20–24	171	26.9
25–29	114	18.0
30 or more	172	27.1
Don't know	11	1.7
Mean years of schooling:	5.3 (IQR: 4–6)	
0	26	4.1
1–6	452	71.2
>6	146	23.0
Don't know	11	1.7
Paternal characteristics:		
Mean years of schooling (in years):	6.6 (IQR: 5–8)	
0	7	1.1
1–6	239	37.6
>6	186	29.3
Don't know	203	32.0
Household characteristics:		
Main breadwinner – father	430	67.7
Main breadwinner – mother	50	7.9
Main breadwinner – other	155	24.4
Main breadwinner is farmer/agricultural worker	434	68.3
Median years continuously living in community	10 (IQR: 5–20)	
Household size (mean)	7.4 (IQR: 5–10)	
Household has electricity	137	21.4
Use of piped water–in–house water supply	170	26.8
Use of improved sanitation (improved pit for toilet)	71	11.2
Household uses firewood for cooking	610	96.1
Floor of the house made of cement	93	14.7
Median travel time to nearest health facility (min)	30.0 (IQR: 25–60)	

IQR – interquartile range

*IQR: first and third quartiles of the interquartile range (Q1–Q3)

Figure 2 further shows the percentage of deceased children 12–59 months of age (n = 372) who received vaccinations against each of the six major preventable childhood diseases by one year of age. Overall, just 36.8% of the children were fully immunized against these diseases before they reached their first birthday. The highest coverage was for Polio 0, BCG, DPT1, and Measles, ranging from 86.0% to 94.4%. The deceased children were least likely to be fully immunized against polio by age one (just 52.7% had had all three doses).

Almost all (92.3%) of the 539 6–59–months–old children received at least one dose of vitamin A before the fatal illness began.

The breakdowns in the Pathway to Survival that contributed to the deaths of the children are presented in Figure 3. This analysis included only the 614 children whose caretakers provided information on the types of actions taken for the illness.

Nearly all (96.1%) of the caregivers of the 614 children recognized that their child had a severe or possibly severe sign or symptom when they first noticed that the child was ill. Care was provided or sought for almost all (95.8%, n = 588) of the children; while 15 (2.4%) children were said to have "died immediately," and no care was given or sought for the other 11 (1.8%).

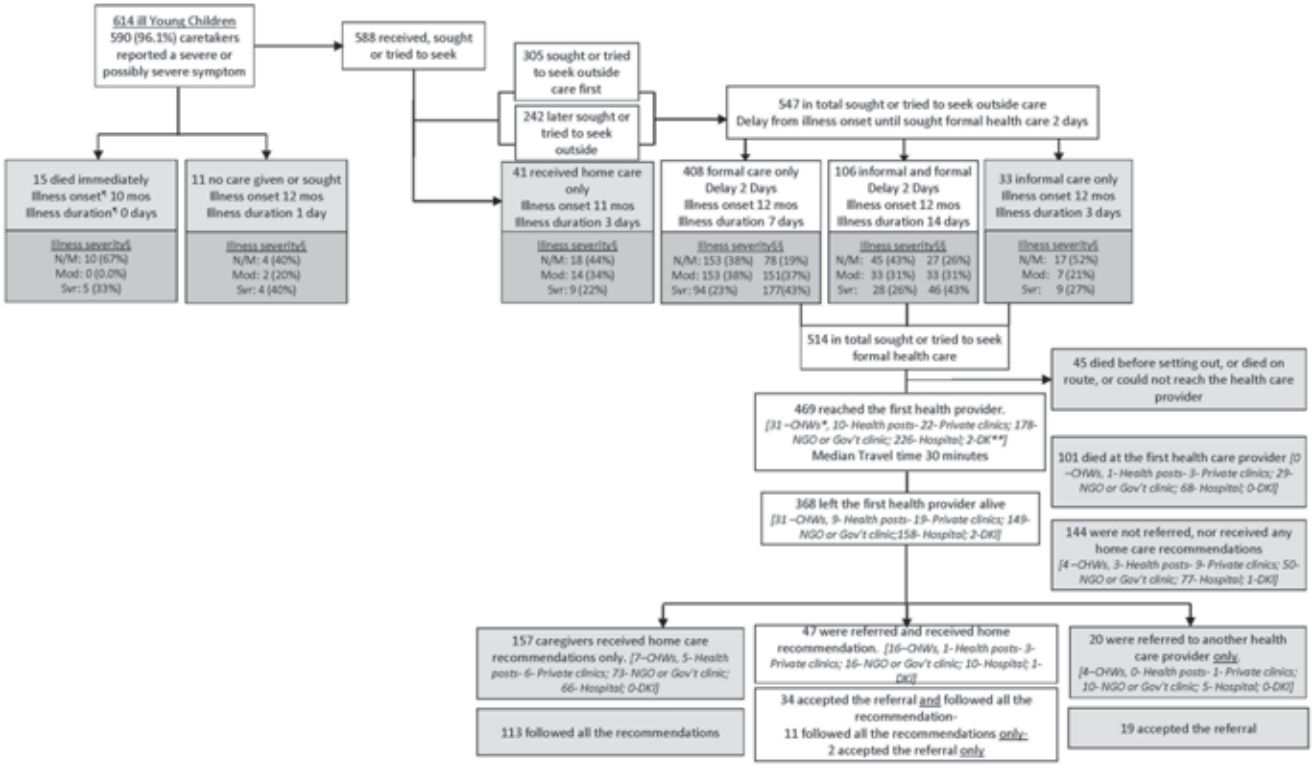


Figure 3. The "Pathway to Survival" for 614 Young Child deaths in Doume, Nguelemendouka and Abong-Mbang districts, in Eastern Region of Cameroon, from 2007-2010. ¶Median values are reported for the age at illness onset, the delay to formal care, and the illness duration due to the skewed values for these variables. §Illness severity at onset. §§Illness severity at onset and when caregiver decided to seek formal care. N/M=normal/mild, Mod=moderate, Svr=severe *CHWs – Trained Community Health worker. **DK Don't know.

The first action taken for about half (51.9%, n = 305) of the 588 children for whom care was given or sought was to seek care outside the home; the other 283 children (48.1%) first received care inside the home, and 242 of these 283 later sought or tried to seek care outside the home. In total then, 547 (89.1%) of the 614 children for whom care–seeking data was available received, sought, or tried to seek care outside the home. When care was sought outside the home, the majority (74.6%, n = 408) received or tried to seek only formal care, ie, care provide by or at either one of the followings: a trained community health worker (CHW), private doctor or NGO/Government center/post or hospital, 106 (19.4%) received or tried to seek both informal, such as care from a traditional healer or from a pharmacist/drug seller, and formal care, and 33 (6.0%) received informal care only. The median duration (delay) from the illness onset until seeking formal care was 2 days (IQR: 1–3 days) both for those who sought or tried to seek both informal and formal care and those who sought or tried to seek only formal care. For both groups as well, the decision to seek formal care was delayed by 2 days (median time) after the onset of the illness (**Figure 4**), regardless of whether formal care was sought from a health worker in the community or at a hospital or other health facility ($\chi^2(2) = 1.261$; $P = 0.2614$). In addition, the median delay was 2 days among children who were perceived to be normal or moderately ill, compared to the median of 2.5 days among those who

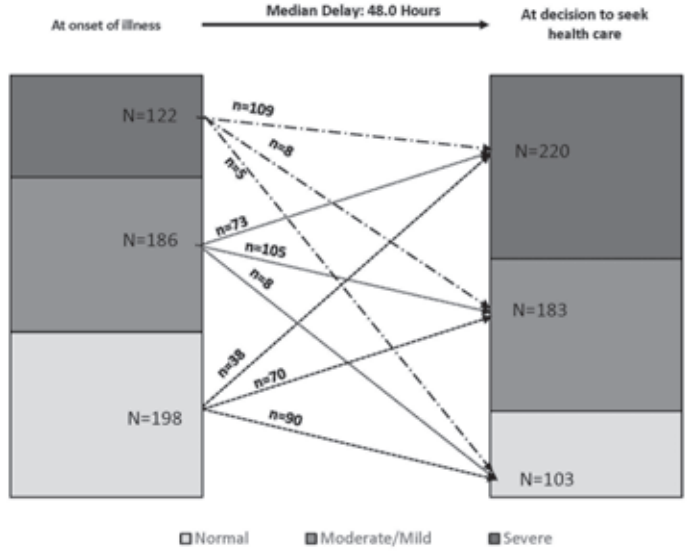


Figure 4. Illness severity ranking at onset and at decision to seek care among children for whom caregivers tried to seek or sought some formal care (N = 506). 8 children had missing information that did not allow their illness severity ranking.

were severely ill when the decision was made to seek formal care. A median test showed that there was no statistically significant difference in delay between the normal/moderately ill and the severely ill children ($\chi^2(1) = 0.831$, $P = 0.3619$).

Among those who sought or tried to seek some formal care (N = 514, including 8 who had missing information on perceived illness severity), the percent of children perceived to be severely ill increased from 24.1% (122 out of 506) at the time of illness onset to 43.5% (or 220 out of 506) when the decision was made to seek formal care (**Figure 4**). Many (n = 111) children who were mildly or moderately ill at the time of illness onset, became severely ill by the time their caregivers decided to seek formal care. In other words, the mean illness severity score increased from 1.66 (±SD = 1.043) at onset of the illness to 2.15 (±SD = 0.923) when the decision was made to seek formal care, and the difference of –0.49 (±SD = 0.893) was statistically significant ($t = -12.35$; $P < 0.0001$).

Of the 514 children for whom caregivers tried to seek some formal care, 45 (8.8%) did not reach the health care facility because they died before setting out, died en route or could not reach the health care provider. The remaining 469 (91.2%) children reached the first health care provider after about 30 minutes median travel time, IQR:15–60–minute. Thirty–one (31) went to a community health worker (CHW), 10 to a health post, 22 to a private doctor or clinic, 178 to an NGO or government clinic, and 226 to an NGO or government hospital, and 2 – for which the name or type could not be identified with the available data.

Out of 469 children that reached a first provider, 101 (21.5%) died at that provider. Approximately half (51.5%, or n = 52) of those children who died at the first provider were judged by their caregivers to be severely ill at the time the decision was made to seek formal care. This compares to slightly more than a third (38.6% or 142 out of 367) of those children who left the first provider alive being judged to be severely ill at the time the decision was made to seek formal care. The difference between the two groups (51.5% vs 38.6%) was statistically significant ($\chi^2_1 = 9.325$; $P < 0.010$.

In addition, about 39% (n = 144) of the 368 that reached a health care provider and left the provider alive were not referred nor given any home care recommendations. The remaining 224 were either only referred (n = 20) to a second health care provider, only received home care recommendations (n = 157), or were referred and received home care recommendations (n = 47). In summary, just 67 (18.2%) of the 368 that left the first provider alive were referred; however, when recommendations were received, or referrals provided, most of the caregivers (77%–82%) followed all the recommendations or accepted the referral and went to a second health care provider.

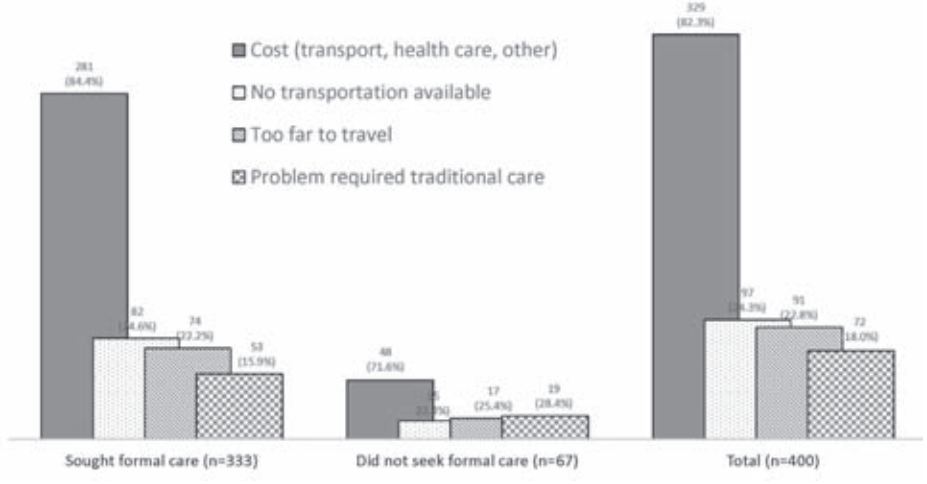


Figure 5. Main care–seeking constraints for child illness (N = 400 caregivers).

Figure 5 explores the care–seeking constraints for fatal child illnesses. In total, 400 of the 588 caregivers (68.0%) whose children received, sought or tried to seek care reported that they had some concerns or problems in seeking care from a health care provider for their child's fatal illness. Cost (82.3%), lack of transport (24.3%) and distance (22.8%) were the primary constraints for care–seeking at a health provider, with more caregivers who did not seek care than those who did seek care reporting that they had a concern or problem.

DISCUSSION

The social autopsy data offer a unique opportunity to assess several households, community and health care system factors related to the children's deaths. Finding that the majority of children in the study area lived in deprived households concurs with several previous studies that demonstrated that the general health status of children from poor families is compromised by their families' circumstances [17–19].

The fact that half of the mothers of the deceased children entered into union or marriage at a young age (less than 18 years of age) is of concern. In actuality, child marriage is a violation of human rights [20], because it compromises the development of girls, and often results in early pregnancy and infant mortality. Many countries, including Cameroon, are signatories to all the major child protection conventions, but their application remains uneven. Progress is needed in this area. Besides, improving access to education among girls and eliminating gender gaps in education are known to be important strategies in ending the practice of child marriage [21].

The characteristic of the majority of households in the study area, especially those in rural zones, was typical of the traditional Bantu dwellings made of sun–dried bricks placed in a wooden frame, with Raffia palm fronds or metal roofing. Besides, it was locally and culturally accepted for households to have a single room that serves for cooking during the daytime and as a sleeping room at night. In addition, the overwhelming majority of households relied on domestically available and affordable energy sources, namely firewood for cooking, and kerosene lamps for lighting. Hence, smoke is vented into the home instead of outdoors, leading to 80% of the children being exposed to some of the highest levels of indoor air pollution in the world [22].

According to the World Health Organization, exposure to indoor air pollution more than doubles the risk of pneumonia and other acute lower respiratory infections (ARLI), particularly among children because they may be more vulnerable to the effects of air pollution [23]. Besides, the proportion of child deaths from pneumonia was 15% in Cameroon [24]. The unpublished VASA study report [25] revealed that pneumonia was responsible for 17%–20% of the deaths by expert algorithm and physician–coded analyses among 1–59 months old children in the study setting. This finding sets the stage for more in–depth pollutant exposure research and intervention. Future study considerations should include direct measures to document the amount and composition of pollutant exposures among children. Until then, replacing the traditional 3–rock cook stove with an improved stove and venting the smoke out of the house through a chimney could significantly improve families' and children's health [26,27].

Deprived or poor households – such as the ones the children were living in before they died—are also known to have increased levels of interrupted breastfeeding and inappropriate complementary/replacement feeding that, in turn, could lead to malnutrition, illness, and mortality [28–30]. The health of about 64% the deceased children whose illness started at 0–23 months old may have also been endangered by their poor nutritional status prior to the illness onset. Indeed, it is estimated that more than one–third of under–five–years–of–age children's deaths are attributable to undernutrition [31].

When the children became fatally ill, almost all of the caregivers recognized symptoms of severe or possibly severe illnesses. And, unlike the deceased newborn cases [11], a greater number of caregivers (83.7%, n = 514) sought or tried to seek some formal care. The only problem with that was the long delay of 2 days from onset of the illness to when the decision was made to seek formal care. As a result, many (n = 111) children were taken for care only after their illness progressed from mild or moderate to severe.

The delay in deciding to seek care (or so–called delay 1) has been described in previous studies and has been shown to result from an inability to recognize the gravity of the illness condition, or a lack of understanding of disease etiologies and cultural traditions that prescribe seeking treatment first from a traditional healer [32–35]. Some authors have posited that the decision to seek care for childhood illness is largely determined not only by the availability of health care services, but also by social and economic factors, such as religious and cultural norms, the cost of seeking health care, and the acceptability of treatment practices [36]. Other argued that past experience with similar illnesses can motivate mothers to play a 'waiting game' to see whether the illness subsides on its own [37]. The reasons for delay 1 in this study setting are unknown. But we suspect the following conditions hindered a timely decision to seek health care: access to public health care throughout this region is limited, with a median travel time of 30 minutes to the usual health facility for our study population, and rural roads are often of poor quality, especially during the rainy season. In addition, public health facilities in the region often face difficulty maintaining adequate medical personnel and supplies of essential medicines resulting in poor quality of care [38]. Likewise, the current study revealed that unaffordable costs for transportation and health care are

key barriers to seeking care in this region, and confirmed findings that suggest a need to mitigate the costs of care–seeking and to provide an effective means of transportation [11].

This delay may have played a major role in the death of the severely ill children who reached the first formal provider and died a few days after. And the fact that this long delay 1 of 2 days did not vary significantly from seeking care at the community or at the facility levels, nor within perceived severity groups at illness onset warrants the need to reinforce the community–based Integrated Management of Childhood Illness (C–IMCI) strategy that improves case management skills of health workers, strengthens the health care system, and addresses family and community practices. The opportunity with C–IMCI to consult a health worker at any time of the day or night, 7 days per week facilitates prompt treatment–seeking and case management [39–41].

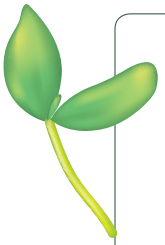
The major limitation of this study was the absence of a comparison group that would allow analysis to test whether there were significant differences between the coverage of interventions among cases (deceased children) and controls (alive children). However, the lack of a comparison group in SA studies is common and not so necessary since we are studying interventions that should be accessible to all children [12]. A second limitation refers to the recall period: the median recall period for the 1–59 months deaths was 2 years (IQR: 2–3years). Given that and added to the fact that the respondents were the main caregivers of the deceased newborns, it is possible that the data may have been affected by different types of biases, including recall bias of past events and the likelihood of providing socially desirable answers to sensitive questions. However, the conversational and prompting modes used during the face–to–face interviews, along with the quality of interviewers/supervisor/trainers may have led to better overall recall of events. In addition, the findings in this study in the Eastern region of Cameroon cannot be applied to the whole country. Different regions in Cameroon exhibit marked socio–demographic and cultural variation, disparate levels of economic development and access to health care, as well as distinct climatic conditions and food production likely to affect child health independently of household or neighborhood economic status.

CONCLUSIONS

In conclusion, as the global health community deliberates the strong likelihood that MDG–4 targets will not be accomplished and about the post–MDG era, it is important that aspects that have been ignored over the past decade find emphasis and support both nationally and globally. The recent social autopsy study conducted in Doume, Nguelemendouka, and Abong–Mbang health districts in the Eastern Region of Cameroon sheds light on the most common household, community and health care system factors that contributed to the deaths of children under five years of age. Among these factors are poor living conditions, poor nutritional status, prevailing customs or cultural practices that lead to exposure to indoor smoke, and health–related behaviors such as delaying the decision to seek care.

Short–term interventions could include the introduction of the C–IMCI program that could increase caregivers' ability to recognize danger signs of child illnesses and facilitate behavior change for timely and appropriate health care–seeking. Building informed demand among children's caregivers to seek prompt treatment from an appropriate provider is an important component of any intervention aimed at improving case management coverage. In addition, keeping improved infant and young child feeding high on the public health agenda is crucial to consolidating gains made during the past two decades.

An improved standard of living such that parents or caretakers can overcome the economic obstacles to seeking basic child health care might be efficacious in the long term.



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REFERENCES

1 United Nations Inter-Agency Group for Child Mortality Estimation. Levels & trends in child mortality: Report 2015. United Nations Children's Fund, New York. Available: http://www.unicef.org/publications/files/Child_Mortality_Report_2015_Web_8_Sept_15.pdf. Accessed: 2 October 2015.

2 United Nations. Millennium Development Goals Report 2015. New York. Available: http://mdgs.un.org/unsd/mdg/Resources/Static/Products/Progress2015/English2015.pdf. Accessed: 10 October 2015.

3 Marmot M. Social determinants of health inequalities. Lancet. 2005;365:1099-104. Medline:15781105 doi:10.1016/S0140-6736(05)74234-3

4 Macassa G, Burström B. Determinants of social inequalities in child mortality in Mozambique: What do we know? What could be done? Afr J Health Sci. 2006;13:139-43. Medline:17348755

5 Grais RF, Dubray C, Gerstl S, Guthmann JP, Djibo A, Nargaye KD, et al. Unacceptably high mortality related to measles epidemics in Niger, Nigeria, and Chad. PLoS Med. 2007;4:e16. Medline:17199407 doi:10.1371/journal.pmed.0040016

6 Kadobera D, Sartorius B, Masanja H, Mathew A, Waiswa P. The effect of distance to formal health facility on childhood mortality in rural Tanzania, 2005–2007. Glob Health Action. 2012;5:1-9. Medline:23151364

7 Frankenberg E. The effects of access to health care on infant mortality in Indonesia. Health Transit Rev. 1995;5:143-63. Medline:10159677

8 Institut National de la Statistique (INS) et ORC Macro.Enquête Démographique et de Santé du Cameroun 2004. Calverton, Maryland, USA: INS et ORC Macro; 2004.

9 Kalter HD, Salgado R, Babille M, Koffi AK, Black RE. Social autopsy for maternal and child deaths: a comprehensive literature review to examine the concept and the development of the method. Popul Health Metr. 2011;9:45. Medline:21819605 doi:10.1186/1478-7954-9-45

10 Institut National de la Statistique (INS) du Cameroun. Rapport national sur les Objectifs du Millénaire pour le dévelopement en 2015. Cameroun, Septembre 2015. Available: http://slmp-550-104.slc.westdc.net/~stat54/downloads/2015/OMD_Rapport_2015_Cameroun.pdf. Accessed: 17 July 2016.

11 Koffi AK, Libite P, Moluh S, Wounang R, Kalter HD. Social autopsy study identifies determinants of neonatal mortality in Doume, Nguelemendouka and Abong–Mbang health districts, Eastern Region of Cameroon. J Glob Health. 2015;5:010413. Medline:26171142 doi:10.7189/jogh.05.010413

12 Boschi-Pinto C, Young M, Black RE. The Child Health Epidemiology Reference Group reviews of the effectiveness of interventions to reduce maternal, neonatal and child mortality. Int J Epidemiol. 2010;39 suppl 1:i3-6. Medline:20348123 doi:10.1093/ije/dyq018

13 Koffi AK, Maina A, Yaroh AG, Habi O, Bensaïd K, Kalter HD. Social determinants of child mortality in Niger: Results from the 2012 National Verbal and Social Autopsy Study. J Glob Health. 2016;6:010603. Medline:26955473 doi:10.7189/jogh.06.010603

14 Aguilar AM, Alvarado R, Cordero D, Kelly P, Zamora A, Salgado R. Mortality Survey in Bolivia: The Final Report. Investigating and Identifying the Causes of Death for Children Under Five. The Basic Support for Institutionalizing Child Survival (BASICS) Project. 1998. Available: http://pdf.usaid.gov/pdf_docs/PNACF082.pdf. Accessed: 14 October 2015.

15 Cronbach LJ. Coefficient alpha and the internal structure of tests. Psychometrika. 1951;16:297-334. doi:10.1007/BF02310555

16 Nunnaly J. Psychometric theory. 1998. New York: McGraw-Hill; 1978.

17 Cameron L, Williams J. Is the relationship between socioeconomic status and health stronger for older children in developing countries? Demography. 2009;46:303-24. Medline:21305395 doi:10.1353/dem.0.0054

18 Houweling TA, Kunst AE. Socio-economic inequalities in childhood, mortality in low- and middle-income countries: a review of the international evidence. Br Med Bull. 2010;93:7-26. Medline:20007188 doi:10.1093/bmb/ldp048

19 Nattey C, Masanja H, Klipstein-Grobusch K. Relationship between household socio-economic status and under-five mortality in Rufiji DSS, Tanzania. Glob Health Action. 2013;6:19278. doi:10.3402/gha.v6i0.19278

20 United Nations. Convention on the elimination of all forms of discrimination against women. Available: http://www.un.org/womenwatch/daw/cedaw/text/econvention.htm. Accessed: 9 February 2017.

21 United Nations Children's Fund. The national strategy to end child marriage and teenage pregnancy 2014/2015 – 2019/2020. A society free from child marriage and teenage pregnancy. 2015. Available: http://www.unicef.org/uganda/NATIONAL_STRATEGY_ON_CHILD_MARRIAGE-PRINT_READY.pdf. Accessed: 13 June 2015.

22 Diette GB, Accinelli RA, Balmes JR, Buist AS, Checkley W, Garbe P, et al. Obstructive lung disease and exposure to burning biomass fuel in the indoor environment. Glob Heart. 2012;7:265-70. Medline:23139916 doi:10.1016/j.gheart.2012.06.016

23 Dherani M, Pope D, Mascarenhas M, Smith KR, Weber M, Bruce N. Indoor air pollution from unprocessed solid fuel use and pneumonia risk in children aged under five years: a systematic review and meta-analysis. Bull World Health Organ. 2008;86:390-398C. Medline:18545742 doi:10.2471/BLT.07.044529

24 World Health Organization. Countdown to 2015. A Decade of Tracking Progress for maternal, Newborn and Child Survival. 2015. Geneva: World Health Organization.

25 Institut National de la Statistique (INS-CAMEROUN) et Child Health Epidemiology Reference Group. (CHERG)- Enquête Autopsie Verbale/ Autopsie Sociale (AVAS). Cameroun 2013. Available: http://www.stat.cm/downloads/2016/VASA_Nov2013.pdf. Accessed: 9 February 2017.

26 Klasen E, Miranda JJ, Khatry S, Menya D, Gilman RH, Tielsch JM, et al. Feasibility intervention trial of two types of improved cookstoves in three resource-limited settings: study protocol for a randomized controlled trial. Trials. 2013;14:327. Medline:24112419 doi:10.1186/1745-6215-14-327

27 Jary HR, Kachidiku J, Banda H, Kapanga M, Doyle JV, Banda E, et al. Feasibility of conducting a randomised controlled trial of a cookstove intervention in rural Malawi. Int J Tuberc Lung Dis. 2014;18:240-7. Medline:24429320 doi:10.5588/ijtld.13.0485

28 Pongou R, Majid E, Salomon JA. Household and community socioeconomic and environmental determinants of child nutritional status in Cameroon. BMC Public Health. 2006;6:98. Medline:16618370 doi:10.1186/1471-2458-6-98

29 Black RE, Allen LH, Bhutta ZA, Caulfield LE, de Onis M, Ezzati M, et al. Maternal and child undernutrition: global and regional exposures and health consequences. Lancet. 2008;371:243-60. Medline:18207566 doi:10.1016/S0140-6736(07)61690-0

30 Chimhuya S, Kambarami RA, Mujuru H. The levels of malnutrition and risk factors for mortality at Harare Central Hospital-Zimbabwe: an observation study. Cent Afr J Med. 2007;53:30-4. Medline:20355679

31 World Health Organization. Global Strategy for Infant and Young Child Feeding. 2003. Available: http://www.who.int/nutrition/topics/global_strategy/en/. Accessed: 9 February 2017.

32 Liu L, Johnson HL, Cousens S, Perin J, Scott S, Lawn JE, et al. Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000. Lancet. 2012;379:2151-61. Medline:22579125 doi:10.1016/S0140-6736(12)60560-1

33 Black RE, Allen LH, Bhutta ZA, Caulfield LE, de Onis M, Ezzati M, et al. Maternal and child undernutrition: global and regional exposures and health consequences. Lancet. 2008;371:243-60. Medline:18207566 doi:10.1016/S0140-6736(07)61690-0

34 Killewo J, Anwar I, Bashir I, Yunus M, Chakraborty J. Perceived delay in healthcare-seeking for episodes of serious illness and its implications for safe motherhood interventions in rural Bangladesh. J Health Popul Nutr. 2006;24:403-12. Medline:17591337

35 Goldman N, Heuveline P. Health-seeking behaviour for child illness in Guatemala. Trop Med Int Health. 2000;5:145-55. Medline:10747275 doi:10.1046/j.1365-3156.2000.00527.x

36 Dillip A, Hetzel MW, Gosoniu D, Kessy F, Lengeler C, Mayumana I, et al. Socio-cultural factors explaining timely and appropriate use of health facilities for degedege in south-eastern Tanzania. Malar J. 2009;8:144. Medline:19563640 doi:10.1186/1475-2875-8-144

37 D'Souza RM. Care seeking behavior. Clin Infect Dis. 1999;28:234. Medline:10064233 doi:10.1086/515120

38 Colvin CJ, de Heer J, Winterton L, Mellenkamp M, Glenton C, Noyes J, et al. A systematic review of qualitative evidence on barriers and facilitators to the implementation of task-shifting in midwifery services. Midwifery. 2013;29:1211-21. Medline:23769757 doi:10.1016/j.midw.2013.05.001

39 Littrell M, Moukam LV, Libite R, Youmba JC, Baugh G. Narrowing the treatment gap with equitable access: mid-term outcomes of a community case management program in Cameroon (2013). Health Policy Plan. 2013;28:705-16. Medline:23144228 doi:10.1093/heapol/czs110

40 Chanda P, Hamainza B, Moonga HB, Chalwe V, Banda P, Pagnoni F. Relative costs and effectiveness of treating uncomplicated malaria in two rural districts in Zambia: implications for nationwide scale-up of home-based management. Malar J. 2011;10:159. Medline:21651828 doi:10.1186/1475-2875-10-159

41 George A, Menotti EP, Rivera D, Montes I, Reyes CM, Marsh DR. Community case management of childhood illness in Nicaragua: transforming health systems in underserved rural areas. J Health Care Poor Underserved. 2009;20(4 Suppl):99-115. Medline:20168036 doi:10.1353/hpu.0.0205

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Toward elimination of mother–to–child transmission of HIV in South Africa: how best to monitor early infant infections within the Prevention of Mother–to–Child Transmission Program

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Background South Africa has utilized three independent data sources to measure the impact of its program for the prevention of mother–to–child transmission (PMTCT) of HIV. These include the South African National Health Laboratory Service (NHLS), the District Health Information System (DHIS), and South African PMTCT Evaluation (SAPMTCTE) surveys. We compare the results of each, outlining advantages and limitations, and make recommendations for monitoring transmission rates as South Africa works toward achieving elimination of mother–to–child transmission (eMTCT).

Methods HIV polymerase chain reaction (PCR) test data, collected between 1 January 2010 to 31 December 2014, from the NHLS, DHIS and SAPMTCTE surveys were used to compare early mother–to–child transmission (MTCT) rates in South Africa. Data from the NHLS and DHIS were also used to compare early infant diagnosis (EID) coverage.

Results The age–adjusted NHLS early MTCT rates of 4.1% in 2010, 2.6% in 2011 and 2.3% in 2012 consistently fall within the 95% confidence interval as measured by three SAPMTCTE surveys in corresponding time periods. Although DHIS data over–estimated MTCT rates in 2010, the MTCT rate declines thereafter to converge with age–adjusted NHLS MTCT rates by 2012. National EID coverage from NHLS data increases from around 52% in 2010 to 87% in 2014. DHIS data over–estimates EID coverage, but this can be corrected by employing an alternative estimate of the HIV–exposed infant population.

Conclusion NHLS and DHIS, two routine data sources, provide very similar early MTCT rate estimates that fall within the SAPMTCTE survey confidence intervals for 2012. This analysis validates the usefulness of routine data sources to track eMTCT in South Africa.

Since 2004, when South Africa officially launched its program to prevent mother–to–child transmission (PMTCT) of HIV, huge strides have been made in curbing the incidence of infant HIV infection. Despite the national antenatal HIV sero–prevalence, as measured among women attending public health facilities, consistently remaining between 29% and 31% since 2004, the number of vertically infected infants has continued to decrease [1–3]. Various methods utilizing different data sets have been employed to monitor the effectiveness of the PMTCT program. Data from the National Health Laboratory Service (NHLS) and the District Health Information System (DHIS) have been used independently to monitor the early mother–to–child transmission (MTCT) rate and the coverage of early infant diagnosis (EID) testing among the HIV–exposed infant population. Furthermore, three national, facility–based South African PMTCT Evaluation (SAPMTCTE) surveys have been conducted since 2010 to assess the effectiveness of the national PMTCT program. We compare the results of each method, outlining their respective advantages and limitations, and make recommendations as South Africa prepares for pre–validation of its elimination of mother–to–child transmission (eMTCT) status [4].

Elimination of mother–to–child transmission

Criteria and processes for validation of eMTCT of HIV have been suggested by the World Health Organization (WHO) [4]. These minimum global standards refer to specific impact and process targets which need to be met prior to certification of eMTCT. The required impact targets are ≤50 new pediatric HIV infections per 100 000 live births and a transmission rate of either <5% in breastfeeding populations or <2% in non–breastfeeding populations.[4] Countries are encouraged to apply for validation of eMTCT once impact targets have successfully been met for one year, process targets for two years, and eMTCT has been achieved in at least one of the lowest–performing sub–national administrative units. In order to achieve eMTCT targets, appropriate monitoring tools need to inform a national validation report that must subsequently be approved by national, regional and global validation committees.

South African Guidelines for Early Infant Diagnosis

In 2004, the South African National Department of Health (NDOH) recommended routine HIV PCR testing in HIV–exposed infants at six weeks of age [5]. Since then, a number of important changes have been made to EID guidelines. Whereas testing symptomatic infants prior to six weeks of age and testing all HIV–exposed infants at six weeks of age has been standard of care for over a decade, in 2013 the additional targeted birth testing of asymptomatic but "high–risk" infants was implemented in some parts of the country [6]. Subsequently, in June 2015, as a means of ensuring earlier detection of intra–uterine infected infants, routine birth testing for all HIV–exposed infants was introduced into national guidelines [5]. Additional changes to EID guidelines include a second HIV PCR test at 10 weeks of age for those who test negative at birth and the falling–away of the standard six–week test (**Table 1**). Furthermore, the test-

Table 1. South African National Guidelines for Early Infant Diagnosis of HIV Exposed Infants [3,5–10]

Year of Guideline	2004	2008	2010	2013	2015
If HIV–exposed & symptomatic:	HIV PCR test at presentation				
If HIV–exposed & asymptomatic:	HIV PCR at ≥6 wks	HIV PCR at 6 wks	HIV PCR at 6 wks	HIV PCR at 6 wks	HIV PCR at birth
If HIV PCR positive:	HIV VL test at baseline Repeat HIV PCR only if child is asymptomatic	HIV VL test at baseline Repeat HIV PCR only if child is asymptomatic	Confirmatory HIV VL: VL >10 000 cps/ml confirms HIV positive status	Confirmatory HIV VL: Any quantified VL confirms HIV positive status	Confirmatory HIV PCR
If HIV PCR negative:	Repeat HIV PCR test if infant symptomatic, and repeat 6 wks after cessation of breastfeeding				
					Repeat HIV PCR at 10 wks
					Repeat HIV PCR at 18 wks (if received 12 wks NVP)
					Repeat HIV PCR if breastfeeding and maternal VL >1000 cps/ml

PCR – polymerase chain reaction, cps/ml – copies per milliliter, wks – weeks, VL – viral load, NVP – Nevirapine

ing method for confirming HIV infection status has changed from an HIV viral load to a confirmatory HIV PCR test [5,8]. These changes in EID guidelines have important implications for monitoring MTCT using routine laboratory data.

Data sources used to monitor MTCT in the PMTCT program

Early MTCT refers to vertical transmission that is acquired either intra–uterine or intrapartum, and is typically monitored between the ages of four to eight weeks of age. In South Africa, early MTCT has been measured using different methodologies from three different data sources, namely the NHLS, the DHIS and three SAPMTCTE surveys. In addition, uptake of early infant testing has been calculated from both NHLS and DHIS data.[1]

The NHLS provides diagnostic services for the whole of the public health sector in South Africa, estimated at 80% of the total population of the country. Every laboratory test is accompanied by an NHLS test requisition form that stipulates identifying details for each patient, the date of specimen collection, the facility at which testing was performed and the type of test requested. This information is entered into the laboratory information system (LIS) together with the test results and stored centrally in the NHLS corporate data warehouse (CDW). Monthly reports are generated detailing the number of HIV PCR tests performed and the number of HIV PCR positive test results for approximately 4000 health care facilities across the country.

The DHIS gathers aggregate data from all health care facilities in each of the 52 health districts in South Africa, and includes HIV PCR results from the NHLS. These data are collected and summated in prescribed registers at each facility. They are then captured electronically in the DHIS and transmitted to provincial and national level for collation. There is monthly reporting at sub–district, district, provincial and national level to track health service delivery. The data elements collected include those that make up the PMTCT indicators.

The SAPMTCTE were national surveys conducted over three consecutive years by the South African Medical Research Council, with the aim of determining the impact of the PMTCT program using a population–based representative sample. The sampling unit of these surveys was primary level clinics reporting at least 130 first DTP immunisations per year [11]. The primary objective of the SAPMTCTE surveys was to determine MTCT of HIV at 6 weeks of age and more recently at 3, 6, 9, 12, 15 and 18 months postpartum. Three surveys have been conducted to date from June to December 2010, August 2011 to March 2012 and October 2012 to May 2013.

METHODS

HIV PCR test data collected between 1 January 2010 and 31 December 2014 from three different sources, the NHLS, the DHIS and SAPMTCTE surveys, were used to compare early MTCT rates across five years (2010–2014). For the SAPMTCTE surveys, the MTCT rates and their 95% confidence intervals were allocated to the year in which each survey was initiated. In addition to early MTCT rates, data from the NHLS and DHIS were used to compare EID coverage.

Early MTCT rates

The NHLS CDW reports the HIV PCR positivity rates in children <2 months of age as a proxy for early MTCT rates by calculating the proportion of HIV PCR positive tests to the total number of HIV PCR tests performed in this age group.

The DHIS indicator used to monitor positivity in HIV–exposed infants around 6 weeks is the "infant first PCR test positive around 6 weeks rate" with a numerator of "infant first PCR positive around 6 weeks" and a denominator of "infant first PCR test conducted around 6 weeks". Around 6 weeks is defined as an infant that is first tested between the ages of 4 and 12 weeks.

The SAPMTCTE surveys enrolled infants attending their 6–week immunisation visit, if they were between 4 and 8 weeks of age, regardless of their mother's HIV infection status and collected dried blood spot (DBS) samples from them. HIV–exposed infants and HIV–infected infants were defined as those that tested DBS HIV ELISA and DBS HIV PCR positive, respectively. The early MTCT was calculated using the number of HIV PCR positive infants as the numerator and DBS HIV ELISA positive with HIV PCR result, as a denominator.

Because the ages of the infants used to calculate early MTCT in the three data sets differed, NHLS CDW data was re–extracted to match the age of HIV PCR testing in the DHIS data, 4–12 weeks of age, and in the SAPMTCTE surveys, 4–8 weeks of age.

Early Infant Diagnosis coverage

The NHLS CDW defines EID coverage as the number of registered HIV PCR tests in infants aged ≤2 months of age divided by the expected number of HIV–exposed infants, expressed as a percentage [1]. The denominator (ie, the HIV–exposed population requiring HIV testing) is calculated using the national registered live births published by STATS SA multiplied by the national maternal antenatal sero–prevalence of HIV reported by the NDOH [3,12].

The DHIS indicator used to monitor EID coverage is the "infant first PCR test around 6 weeks uptake rate" with a numerator of "infant first PCR test conducted around 6 weeks" and a denominator of "live births to HIV positive women". To account for potential under–reporting of infants born to HIV–infected mothers in DHIS, an alternative denominator is also used that estimates HIV–exposed infant population by multiplying 'total live births to all women', captured by DHIS, with national maternal antenatal HIV sero–prevalence, reported by the NDOH [3].

RESULTS

Early MTCT rates

The early MTCT rates as determined from NHLS data compare closely with results from the SAPMTCTE surveys, differing by 0.7% in 2010, 0.0% in 2011, and –0,2% in 2012 (**Table 2**). When the NHLS data are re–adjusted to only include HIV PCR tests performed for the same age ranges as the SAPMTCTE surveys (ie, infants 4–8 weeks of age), the NHLS early MTCT rate per year from 2010–2014 decreases uniformly by 0.1% (**Table 2**, Data set 4). Importantly, after matching the age ranges of infants in the NHLS and SAPMTCTE data, the NHLS early MTCT rates consistently fall within the 95% confidence interval as measured by three SAPMTCTE surveys in corresponding time periods (**Table 2**, Data set 3).

The number of HIV PCR tests as recorded by the DHIS is consistently higher than for NHLS data (**Table 2**). The same is true for the calculated early MTCT rate, except for the 2014 estimate. The DHIS early MTCT rate was reported as more than double the NHLS and SAPMTCTE MTCT rates in 2010 (**Table 2**). However, this rate falls dramatically over the next two years to lie within the SAPMTCTE survey's 95% confidence interval for 2012.

When the NHLS data was adjusted to include HIV PCR tests performed on infants 4–12 weeks of age, the early MTCT rates for all years increased (**Table 2**, Data set 5). In 2013 and 2014 the NHLS early MTCT rates were higher than the DHIS rates by 0.2% and 0.5%, respectively (**Table 2**).

Table 2. Early HIV transmission rates in South Africa 2010–2014*

	Data sets	Age	2010	2011	2012	2013	2014
1)	NHLS HIV PCR tests	<2months	119808	164181	184400	195188	222559
	NHLS HIV PCR+ tests	<2months	5282	4609	4440	3912	4054
	NHLS % positive HIV PCR tests	<2months	4.2%	2.7%	2.4%	2.0%	1.8%
2)	DHIS HIV PCR tests	±6 weeks	178241	211942	237869	243786	247037
	DHIS HIV PCR+ tests	±6 weeks	17528	9556	6611	5184	4089
	DHIS % positive HIV PCR tests	±6 weeks	9.0%	4.3%	2.7%	2.1%	1.6%
3)	SAPMTCTE MTCT rate (95% confidence intervals)	4–8 weeks	3.5% (2.9%–4.1%)	2.7% (2.1–3.2%)	2.6% (2.0–3.2%)		
4)	NHLS HIV PCR tests	4–8 weeks	113722	157411	176787	186969	208364
	NHLS HIV PCR+ tests	4–8 weeks	4849	4271	4110	3579	3624
	NHLS % positive HIV PCR tests	4–8 weeks	4.1%	2.6%	2.3%	1.9%	1.7%
5)	NHLS HIV PCR tests	4–12 weeks	139517	187020	206990	216410	236708
	NHLS HIV PCR+ tests	4–12 weeks	7158	6125	5823	5064	5106
	NHLS % positive HIV PCR tests	4–12 weeks	4.9%	3.2%	2.7%	2.3%	2.1%

NHLS – National Health Laboratory Service, PCR – polymerase chain reaction, SAPMTCTE – South African PMTCT Evaluation, DHIS – District Health Information System

*Comparison of MTCT rates for NHLS, DHIS and SAPMTCTE are tabulated in data sets 1)–3). In addition to the routine NHLS data reported at 1) <2months of age, NHLS data are presented at ages 4) 4–8 weeks and 5) 4–12 weeks, to more closely approximate the eligible age group in the SAPMTCTE surveys and reported age group in the DHIS data respectively.

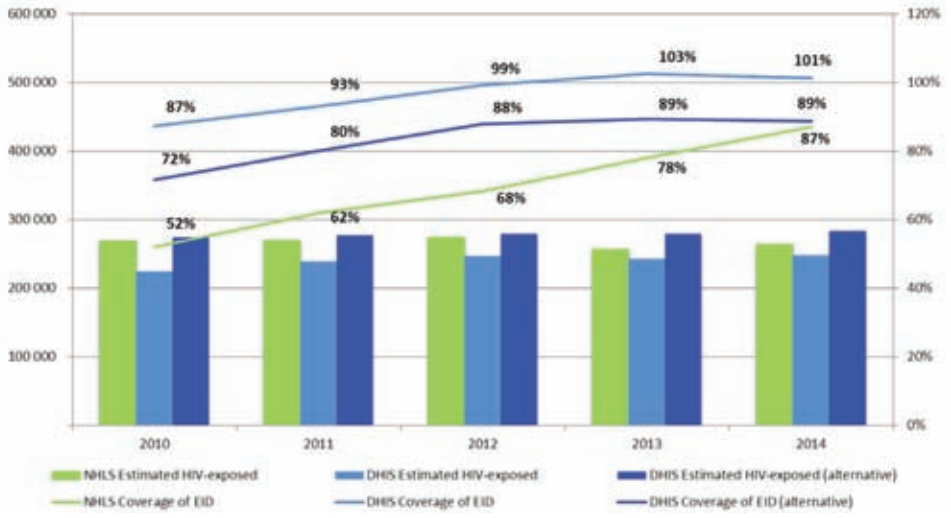


Figure 1. Early Infant Diagnosis Coverage rates in South Africa 2010–2014. The bar graph represents the population of HIV-exposed infants as estimated by NHLS, DHIS and from an alternative DHIS calculation and the line graphs represent the coverage of EID for each data set.

EID coverage

National EID coverage as determined from NHLS data are seen to increase steadily from 52% in 2010 to 68% in 2012 and 87% in 2014 (**Figure 1**). Alternatively, EID coverage as reported from DHIS data appears to be consistently higher and exceeds 100% by 2013. However, when the alternative DHIS denominator is used, EID coverage converges with that reported by the NHLS over time with only a 2% difference in 2014 (**Figure 1**).

Early MTCT and EID coverage rates between 2010 and 2014 showed similar patterns to the national one for all nine provinces (data not shown).

DISCUSSION

This analysis shows that data from routine sources, namely the NHLS and DHIS, produce similar results for monitoring the effectiveness of South Africa's PMTCT program. The accuracy of the early MTCT rates calculated from these distinct routine data sets was verified by comparing them to the SAPMTCTE surveys conducted in the same year, demonstrating that results from routine data sources lie within the 95% confidence intervals of the surveys.

The differences between DHIS and NHLS data in 2010–2012, and the remarkable reduction in MTCT in DHIS data are likely attributable to quality improvement training in the field after it was found that health care workers were reporting the DHIS indicators incorrectly (ie, reporting all HIV PCR tests performed on children of all ages instead of reporting the first HIV PCR test performed on infants aged around 6 weeks) [13].

By 2012, the higher number of HIV PCR tests recorded by the DHIS likely reflects an inclusion of 8–12 week old infants as compared with the NHLS data that excluded this age group and included the 0–4 week age group where very little HIV PCR testing was performed. From 2013, when targeted birth testing of neonates was introduced into the South African guidelines, the decreasing difference in the number of HIV PCR tests performed according to DHIS and NHLS is likely attributable to neonatal testing being included in the NHLS data but excluded from the DHIS data because no mechanism was yet in place for health care workers to report on birth testing. Furthermore, it is postulated that an increase in confirmatory HIV PCR testing, resulting in double counting, may be the explanation for the higher early MTCT rates in 2013 and 2014 in the NHLS vs the DHIS data.

Both NHLS and DHIS document an increase in infant HIV testing coverage between 2010 and 2014 with a convergence in both the absolute numbers tested as well the overall coverage rates.

The use of multiple methodologies to monitor the same PMTCT targets was initially needed to measure national PMTCT effectiveness. The similarities between survey results and routine data sources obviates the urgent need for continued, regular parallel surveillance activities that are expensive and resource and labor intensive.

Limitations

There are clear requirements and limitations to using routine NHLS and DHIS data to monitor early MTCT rates and EID coverage, as well as limitations to the SAMTCTE surveys to calculate MTCT rates.

The use of routine laboratory data to monitor the PMTCT program requires accurate information to be provided on laboratory requisition forms and reliable data capturing from the requisition forms into the LIS. Importantly, for this data to be a true reflection of the country's MTCT rate there must be close to 100% testing coverage, close to zero missed diagnostic opportunities in the laboratory and accurate collection of age data [14]. Missed diagnostic opportunities are defined as samples yielding neither a positive or negative result related to pre–analytical (eg, insufficient sample for processing) and analytical errors (eg, indeterminate or invalid results). A further important limitation is that there is currently no unique identifier for individual patients and no accurate means of de–duplicating test result data. Therefore, infants with multiple HIV PCR tests cannot be distinguished from infants with a single HIV PCR test. Whereas in the past it was assumed that very few infants would access more than one HIV PCR test by 2 months of age, current guidelines recommend confirmatory HIV PCR testing for those infants who test positive and repeat testing for those infants who are symptomatic. Hence, reliable MTCT rates, including post–natal transmission, can no longer be calculated from routine NHLS data without the introduction of unique patient identifiers. The NDOH has communicated that unique patient identifiers will likely be implemented in all public sector facilities in the 2016/17 financial year (M Wolmarans, Chief Director, Strategic Planning, NDOH. Personal communication, February 15, 2016).

Regarding calculating EID coverage from NHLS data, in addition to challenges in de–duplicating data as noted above, limitations include calculating the number of HIV exposed infants requiring testing (ie, the denominator) from national antenatal maternal sero–prevalence data and STATS SA registered live birth data. As these are published after a lag of 2–3 years, EID coverage for 2014 has been calculated based on the ANC Maternal Sero–prevalence data from 2013 and, hence, may not be accurate. Since a proportion of live births registered are from the private health care sector, the number of HIV–exposed infants may be overestimated accounting for a lower EID coverage.

Limitations to the use of DHIS data primarily relate to training health care workers to capture the correct information in a consistent manner. While this undoubtedly has improved over recent years, with practical data improvement interventions found to significantly increase the completeness and accuracy of the data used to monitor PMTCT services in South Africa, there remain a great number of challenges [15]. For instance, because an unknown number of women deliver without any or recent HIV testing or do not disclose their HIV positive status to health care workers in the labor ward, the "live births to HIV positive women" is likely under reported. Hence, the denominator used to calculate EID coverage is too low resulting in an over–estimation of coverage that exceeds 100% by 2013 [16]. As demonstrated, this can be addressed by using an alternative denominator to estimate the HIV–exposed infant population. Data from the SAPMTCTE survey further support the likelihood that determining the HIV–exposed infant population from maternal history taking will over–estimate EID coverage. The SAPMTCTE survey's found that 3–4% of HIV positive women did not report being positive, either because they did not know their status, for reasons which include seroconversion during pregnancy, or chose not to disclose [11].

Limitations of the SAPMTCTE survey primarily relate to sampling. The surveys provide data for healthy infants presenting for immunisation only, excluding infants who were ill at the first immunisation visit, those who had failed to present for immunisation, and those who had died by 6 weeks of age. Hence, the point–estimate is likely an under–estimation of true early infant HIV infection prevalence [17].

Advantages and disadvantages

Whereas each methodology has its own advantages, disadvantages and challenges, it is important to appreciate that there are certain differences between the data sources that cannot be controlled for. Both DHIS and NHLS record HIV PCR data for all infants known to be HIV exposed and tested whereas the SAPMTCTE surveys exclude certain groups of infants who are possibly at high risk of HIV–infection [18]. On the other hand, the SAPMTCTE surveys tested all infants for HIV–exposure and are therefore inclusive of mothers who do not report being HIV positive. Whereas repeat HIV PCR tests on the same patient are included in both the DHIS and NHLS data, the SAPMTCTE surveys do not include duplicate testing.

Clear advantages of using NHLS data are that it allows for near real–time monitoring of early MTCT and EID coverage and comes at very little additional cost. In contrast, DHIS data takes time to collate and

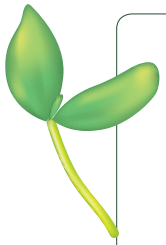
comes at much greater expense. Conversely, a distinct disadvantage of the NHLS CDW to DHIS is that the LIS does not hold clinical data. While the SAPMTCTE surveys are likely to provide the most accurate data, they are expensive and time consuming. Ideally, national–level surveys should be conducted periodically; reserved for validating routine data sources; and answering specific, more detailed questions where no other data are available. Examples include determining the rate of linking HIV PCR positive infant to care, and the interval between infant diagnosis and initiation of treatment.

The way forward

There is undoubtedly scope for improvement in the accurate and timely reporting of PMTCT targets required to achieve elimination. By merging DHIS and NHLS CDW data, a streamlined and efficient method could be forged from current routine monitoring activities. Although the LIS does not hold clinical data, there are opportunities of addressing this by incorporating NHLS requisition forms with the appropriate clinical data populated within the CDW. This would enable clinical data from across the PMTCT cascade to be captured, including data on maternal treatment regimens, infant linkage into care, infant treatment initiation and retention in care. This will preclude the unnecessary duplication of data capturing among health care workers of laboratory data and provide a more robust data set from which to monitor the effectiveness of the PMTCT program at all levels of health care delivery. A consolidated monitoring tool will, nevertheless, pose certain challenges. In particular, the accurate and consistent capturing of a prescribed minimum clinical data set will need to be strictly adhered to.

Access to accurate clinical information will be important for documenting the process targets for eMTCT validation particularly as South Africa recommends breastfeeding but has no system for monitoring final MTCT rates. Furthermore, a unique patient identifier, employed from birth, (eg, printing patient–retained immunisation booklets with unique barcodes that can be captured within the LIS) will be a prerequisite in order to accurately calculate MTCT rates using routine laboratory data. These challenges will be easier to overcome if there is a consolidated effort between clinical and laboratory personnel and a clear directive from the NDOH.

The effectiveness of South Africa's PMTCT program, as determined by the early MTCT rate and EID coverage, has been monitored in parallel using routine laboratory data and operational data collected by each district in the country. Additionally, three national surveys have been conducted between 2010 and 2012, evaluating the effectiveness of the PMTCT program on early MTCT. All three methodologies provide very similar early MTCT rates, with the laboratory and DHIS estimates falling within the survey confidence intervals. These surveys validate the accuracy, and therefore usefulness, of routine data sources, and raise questions about the continued value of regular parallel surveillance activities. As recent changes in national EID guidelines pose new challenges to the accuracy of both NHLS and DHIS data, the continued value of SAPMTCTE surveys will be in periodically validating routine data methods. By introducing unique patient identifiers and consolidating clinical information within the LIS, a more efficient method of monitoring the effectiveness of the national PMTCT program using routine laboratory data are envisaged. This will not only preclude unnecessary duplication of data capturing within the DHIS but also reliably inform eMTCT targets. By outlining the value of routine laboratory data, it is anticipated that these findings will inform South Africa's pediatric HIV surveillance systems as well as other countries monitoring early MTCT rates and EID coverage.



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REFERENCES

1 Sherman GG, Lilian RR, Bhardwaj S, Candy S, Barron P. Laboratory information system data demonstrate successful implementation of the prevention of mother-to-child transmission programme in South Africa. S Afr Med J. 2014;104(3 Suppl 1):235-8. Medline:24893499 doi:10.7196/SAMJ.7598

2 Shisana O, Rehle T, Simbayi LC, Zuma K, Jooste S, Zungu N, et al. South African National HIV Prevalence, Incidence and Behaviour Survey, 2012. Cape Town: Human Sciences Research Council; 2014. Available: http://www.hsrc.ac.za/uploads/pageContent/4565/SABSSM%20IV%20LEO%20final.pdf. Accessed: 15 February 2016.

3 National Department of Health. The 2013 National Antenatal Sentinel HIV Prevalence Survey South Africa. Pretoria: National Department of Health; 2015. Available: http://www.health.gov.za/index.php/2014-03-17-09-09-8/reports/category/176-reports-2015. Accessed: 15 February 2016.

4 World Health Organization. Global Guidance on Criteria and Processes for Validation: Elimination of Mother-to-Child Transmission (EMTCT) of HIV and syphilis. Geneva: WHO; 2014. Available: http://apps.who.int/iris/bitstream/10665/112858/1/9789241505888_eng.pdf?ua=1&ua=1. Accessed: 21 February 2016.

5 National Department of Health. National Consolidated Guidelines for the Prevention of Mother-to-Child Transmission of HIV (PMTCT) and the Management of HIV in Children, Adolescents and Adults. Pretoria: National Department of Health; 2015. Available: http://www.sahivsoc.org/upload/documents/ART%20Guidelines%2015052015.pdf. Accessed: 21 February 2016.

6 National Department of Health. National Antiretroviral Treatment Guidelines. Pretoria: National Department of Health; 2004.

7 National Department of Health. The South African Antiretroviral Treatment Guidelines 2013 PMTCT Guidelines: revised March 2013. Pretoria: National Department of Health; 2013. Available: http://www.up.ac.za/media/shared/Legacy/sitefiles/file/45/1335/877/pmtctguidelines_march2013_doh.pdf. Accessed: 21 February 2016.

8 National Department of Health. National Consolidated Guidelines for the Prevention of Mother-to-Child Transmission of HIV (PMTCT) and the Management of HIV in Children, Adolescents and Adults. Pretoria: National Department of Health; 24 December 2014. Available: http://www.sahivsoc.org/upload/documents/HIV%20guidelines%20_Jan%202015.pdf. Accessed: 21 February 2016.

9 National Department of Health. Policy and Guidelines for the Implementation of the PMTCT Programme. Pretoria: National Department of Health; 2008. Available: http://www.ilo.org/wcmsp5/groups/public/—ed_protect/—protrav/—ilo_aids/documents/legaldocument/wcms_125633.pdf. Accessed: 21 February 2016.

10 National Department of Health. Guidelines for the Management of HIV in Children. Pretoria: National Department of Health; 2010. Available: http://www.sahivsoc.org/upload/documents/Guidelines_for_Management_of_HIV_in_Children_2010.pdf. Accessed: 21 February 2016.

11 Goga AE, Jackson DJ, Lombard CJ; SAPMTCTE study group. Early (4-8 weeks post-delivery) Population-level Effectiveness of WHO PMTCT Option A, South Africa, 2012-2013. Available: http://www.mrc.ac.za/healthsystems/SAPMTCTEReport2012.pdf. Accessed: 08 March 2016.

12 Statistics South Africa. Recorded live births 2014. Pretoria: Statistics South Africa; 2015. Available: http://www.statssa.gov.za/publications/P0305/P03052014.pdf. Accessed: 15 February 2016.

13 Barker P, Barron P, Bhardwaj S, Pillay Y. The role of quality improvement in achieving effective large-scale prevention of mother-to-child transmission of HIV in South Africa. AIDS. 2015;29 Suppl 2:S137-43. Medline:26102624 doi:10.1097/QAD.0000000000000718

14 World Health Organization. A Short Guide on Methods Measuring the Impact of National PMTCT Programmes Towards the Elimination of New HIV Infections Among Children by 2015 and Keeping Their Mothers Alive. Geneva: WHO; 2012. Available: http://apps.who.int/iris/bitstream/10665/75478/1/9789241504362_eng.pdf. Accessed: 8 March 2016.

15 Mphatswe W, Mate KS, Bennett B, Ngidi H, Reddy J, Barker PM, et al. Improving public health information: a data quality intervention in KwaZulu-Natal, South Africa. Bull World Health Organ. 2012;90:176-82. Medline:22461712 doi:10.2471/BLT.11.092759

16 Technau K-G. Can a routine peri-partum HIV counselling and testing service for women improve access to HIV prevention, early testing and treatment of children? Faculty of Health Sciences. Johannesburg: Department of Paediatrics & Child Health, University of the Witwatersrand; 2009.

17 Goga AE, Dinh TH, Jackson DJ; SAPMTCTE study group. Evaluation of the Effectiveness of the National Prevention of Mother-to-Child Transmission (PMTCT) Programme Measured at Six Weeks Postpartum in South Africa, 2010. Available: http://www.mrc.ac.za/healthsystems/SAPMTCTE2010.pdf. Accessed: 15 February 2016.

18 Woldesenbet SA, Jackson D, Goga AE, Crowley S, Doherty T, Mogashoa MM, et al. Missed opportunities for early infant HIV diagnosis: results of a national study in South Africa. J Acquir Immune Defic Syndr. 2015;68:e26-32. Medline:25469521 doi:10.1097/QAI.0000000000000460

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Improving coverage measurement for reproductive, maternal, neonatal and child health: gaps and opportunities

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Background Regular monitoring of coverage for reproductive, maternal, neonatal, and child health (RMNCH) is central to assessing progress toward health goals. The objectives of this review were to describe the current state of coverage measurement for RMNCH, assess the extent to which current approaches to coverage measurement cover the spectrum of RMNCH interventions, and prioritize interventions for a novel approach to coverage measurement linking household surveys with provider assessments.

Methods We included 58 interventions along the RMNCH continuum of care for which there is evidence of effectiveness against cause–specific mortality and stillbirth. We reviewed household surveys and provider assessments used in low– and middle–income countries (LMICs) to determine whether these tools generate measures of intervention coverage, readiness, or quality. For facility–based interventions, we assessed the feasibility of linking provider assessments to household surveys to provide estimates of intervention coverage.

Results Fewer than half (24 of 58) of included RMNCH interventions are measured in standard household surveys. The periconceptional, antenatal, and intrapartum periods were poorly represented. All but one of the interventions not measured in household surveys are facility–based, and 13 of these would be highly feasible to measure by linking provider assessments to household surveys.

Conclusions We found important gaps in coverage measurement for proven RMNCH interventions, particularly around the time of birth. Based on our findings, we propose three sets of actions to improve coverage measurement for RMNCH, focused on validation of coverage measures and development of new measurement approaches feasible for use at scale in LMICs.

New calls for investment in reducing mortality among women, newborns and children are welcome [1], especially to the extent that they are tightly focused on delivering interventions of proven effectiveness at high, sustained, and equitable levels of coverage. Also welcome is a new emphasis on accountability in women's and children's health [2]. Taken together, the global agendas for reproductive, maternal, newborn, and child health (RMNCH) and for accountability rest on the assumption that country governments and development partners will generate or have access to a minimum set of timely, high–quality, representative data to inform their policy and program decisions.

Regular monitoring of population–based coverage levels for RMNCH is central to assessing progress toward national and international health goals

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(**Box 1** provides definitions for "intervention coverage" and other terminology used in this paper) [3]. Coverage estimates that guide decisions must provide a valid measure of coverage in a population, be sensitive to changes in program effort, and be reliable across settings and over time. But measuring population–based coverage is not easy (**Box 2**) [5]. A particularly challenging issue is ensuring that the denominator for a coverage indicator is representative of all women or children who need an intervention.

There is increasing recognition that caregivers cannot report accurately during a household survey interview about whether they or their child received some interventions, especially when the caregiver does not know the specific clinical details of the intervention (eg, which drug was prescribed). This consideration has led to recommendations that reports of where careseeking occurred, collected through household surveys, be linked to assessments of the interventions provided by service providers in order to support estimates of population coverage (hereafter referred to as a "linking approach" to coverage measurement) [3].

In this article we present an analysis of the current state of coverage measurement for interventions across the RMNCH continuum of care. One objective of this analysis is to identify gaps in coverage measurement and assess the extent to which current approaches to coverage measurement cover the spectrum of RMNCH interventions. A second objective is to determine the RMNCH interventions for which linking

Box 1. Definition of terms

Intervention coverage. The proportion of a defined population in need of an intervention that actually receive it (usually measured in a probability sample of the population).

Linking studies. Studies that link caregivers' reports of where care was sought with assessments of the interventions delivered by service providers.

Readiness. A measure of whether a service provider is prepared to provide an intervention, taking into account the presence of the necessary drugs, commodities, and trained and supervised staff to administer the intervention to individuals in need.

Quality of care. A measure of whether an individual in need of an intervention received that intervention from a service provider, including appropriate diagnosis and treatment.

Reliability. A measure of whether an indicator provides a consistent measure of population intervention coverage across samples, most typically thought of as the precision of a point estimate.

Validity. A measure of whether an indicator provides an unbiased measure of true population intervention coverage.

Validation study. An assessment of the extent to which a measure fulfils its intended purpose. This is generally by means of an analytic study which systematically assesses measurement errors and biases and compares data to a "gold standard" or true value, where available.

Box 2. Key issues in measuring intervention coverage

These key issues, and other sources of error in survey measurement of intervention coverage, have been extensively discussed by Eisele and colleagues [4].

Defining the denominator. The denominator should include only those individuals who are in need of an intervention. These individuals may be identified based on age and/or sex, an event such as pregnancy or childbirth, or a diagnosis of disease. Information error or bias can result in misclassification of individuals as being in (or not in) the denominator.

Defining the numerator. The numerator should include individuals who are in need of an intervention and who received that intervention. Information error and bias may affect the identification of individuals in the numerator.

Information error. Information error occurs when survey respondents provide a response even when they do not understand the question or do not know the answer, resulting in potential misclassification. Information error is random and increases the variance of a coverage estimate but does not affect the point estimate. The length of the recall period, question wording, and type of information the respondent is asked for can all contribute to information error.

Information bias. Information bias occurs when there is systematic error in providing information on the numerator or denominator. It is non–random and can result in under– or over–estimation of the point estimate. Many factors can contribute to information bias, including poor question wording (eg, non–neutral questions), long recall periods leading to recall error or age or date heaping, and the social desirability of one or more of the responses.

approaches are most needed and feasible. We assess both direct measurement of intervention coverage and the measurement of health provider readiness to deliver an intervention and/or the quality of intervention delivery ("quality of care"). We synthesize our findings as a basis for defining gaps and propose action steps to improve the measurement of coverage for MNCH interventions.

METHODS

Interventions included in the review

This review focuses on life–saving interventions across the RMNCH continuum of care that are directed against major causes of maternal, newborn, and under–five mortality and stillbirths, and for which there is clear evidence of effectiveness. The list of interventions included in the Global Investment Framework for Women's and Children's Health provided a starting point for identifying these interventions [1]. We considered both biomedical interventions and behaviors, such as the practice of exclusive breastfeeding or sleeping under a bednet (often treated as interventions for global monitoring purposes). The "essential newborn care" intervention was broken into its component practices, including thermal care, immediate breastfeeding, and chlorhexidine for umbilical cord cleansing. Water and sanitation interventions were added based on evidence of their effectiveness in reducing under–five morbidity and mortality [6]. The appendix lists the references of published peer–reviewed articles that describe the underlying evidence base. Typically, this evidence is a systematic review of the published literature on effectiveness, but occasionally it is based on consensus among experts, for example where interventions are established in practice and an evaluation of effectiveness has not been conducted, or where the lack of clinical equipoise has led to such evaluations being considered unethical. We consider measurement issues separately for the following groups of interventions: periconceptional (reproductive), antenatal, intrapartum, postnatal, feeding, under–five, and cross–cutting environmental.

Types of data that are the focus of the review

For each life–saving intervention addressed by this review, we indicate the possible mode(s) of delivery for the intervention (facility–based, community–based, outreach, and/or behavioral), and identify current sources of population–based coverage data and, for facility–based interventions, readiness or quality of care data that could be linked with careseeking data to produce coverage estimates. For coverage measurement, included data sources must provide representative information on both the numerator (individuals in need of an intervention who received it) and denominator (all individuals in need of an intervention).This review only considers population–based data from surveys and other sources that are administered regularly on a large scale (generally at national level) in low– and middle–income countries. More specialized, bespoke surveys (for example, special surveys conducted for effectiveness or efficacy studies) are not included, as these surveys typically provide data for only one country (or more commonly a sub–national area within a country) and are not a useful data source for most countries seeking to track their progress toward RMNCH goals. The review does not address the practical details of survey design such as sampling strategies and detailed sample size issues.

Population–based coverage data

Household surveys are the major source for population–based intervention coverage data in low– and middle–income countries. These surveys are particularly valuable because they typically seek to interview a representative sample of the population, and thus provide measures of coverage that take into account the entire population and for which uncertainty estimates can be calculated. This review includes only surveys with a representative sampling design that provide data at national scale and at regular intervals, the Demographic and Health Surveys (DHS) and Multiple Indicator Cluster Surveys (MICS) [7,8]. These are the largest international household survey programmes on population and health, and the two main sources for survey–based coverage estimates used in global databases [9]. We consider both survey programmes in this review. DHS has coordinated more than 325 nationally representative surveys in 91 countries since 1985, and MICS has carried out 279 surveys in 109 countries since 1995. Survey questionnaires are defined and revised through consultative processes that include stakeholders at global and country level. Over time, the two survey programmes have included an increasing number of coverage indicators along the continuum of RMNCH, including all the categories addressed by this review. In addition to measuring the coverage of biomedical interventions, the survey programmes measure the prevalence of behaviors such as feeding practices, as well as the coverage of water and sanitation interventions. Both programmes provide estimates for internationally agreed–upon indicators for monitoring progress in RMNCH.

Assessment of coverage measurement

For each intervention, we first assessed whether it would be theoretically possible for a representative household survey to establish the coverage denominator, ie, the population in need of the intervention. Our assessment was based on the indications for receiving a particular intervention (for example, whether the intervention is to be given to all children within a particular age range or only to children with a particular diagnosis). We considered that for preventive interventions targeted based on age or other conditions (eg, pregnancy), it would generally be possible to establish an appropriate denominator in a household survey, whereas for treatment interventions requiring a diagnosis or recognition of specific symptoms, it would be possible to establish a denominator only for easily recognizable symptoms such as diarrhea.

We reviewed the questionnaires from MICS Round 5 and DHS Phase 6 for each RMNCH intervention to determine whether the surveys provided measures of the numerator and denominator for the coverage indicator. We also noted the reference period for the coverage indicator, that is, the time period over which the indicator is measured and calculated, generally expressed as an interval of time preceding the survey interview.

Routine health system and program data

Routine data collected via the health system or by implementing programmes may also have some potential for use in estimating RMNCH intervention coverage. Potential advantages of routine data include their availability at a relatively low cost, on a continuous basis, and at facility or district level. In addition, routine data have the potential to provide information on services in greater detail than can be ascertained from respondent recall in household surveys.

However, routine data also have important limitations. Denominators are limited to those who are in contact with the health system, and therefore do not represent the population as a whole. Numerators may be over–counted, especially for services like vitamin A or immunizations that may be delivered both in facilities and through community–based activities or child health days. Many RMNCH indicators of interest are simply not available through routine data, because the numerator, denominator, or both are not collected. Routine health systems in most low– and middle–income countries are also characterized by poor data quality and completeness, and do not include important variables needed to assess equity. Some routine data may be out of date, or may only be updated irregularly. For these reasons, routine data have not been recommended in many settings for tracking key outcome and coverage indicators, and are not considered as a source for intervention coverage data for the purposes of this review.

Readiness and quality of care data

Data on service provider readiness and quality of care are typically collected through a survey or census of health providers – which may include health centers, referral facilities, and community health workers. We define readiness as the presence of the necessary drugs, commodities, and/or trained and supervised staff to administer the intervention to individuals in need. Measurements of quality require an observation–based assessment of whether an intervention was actually received by individuals in need of the intervention, but readiness variables are often used as proxies for quality. Health provider surveys record information on readiness components, and may also include observations of service provision with or without an independent assessment of the client's need for the intervention. For this review, we sought to include assessments of the provision of RMNCH interventions that are administered regularly, in multiple countries, and at national scale. We excluded one–time or single–country assessments, as well as special assessments conducted for a specific study. There was substantial variation in the type of data collected by readiness assessments; we included any assessment that collected data on the availability of the necessary drugs and commodities to deliver the interventions in this review.

To identify provider assessments meeting these criteria, we hand–searched a 2009 review of health facility survey methods [10] as well as the presentations from a technical consultation on linking household surveys and provider assessments [11].

We identified five provider assessments that met our inclusion criteria: the World Health Organization (WHO)'s Service Availability and Readiness Assessment (SARA), the DHS Program's Service Provision Assessment (SPA), MEASURE Evaluation's Rapid Health Facility Assessments (R–HFA) and Quick Investigation of Quality (QIQ), and WHO's IMCI quality of care assessments (previously the IMCI–MCE Health Facility Survey) (**Table 1**).

For each intervention, we reviewed the questionnaires from these provider assessments to determine whether they assessed readiness, observation–based quality of care, or neither. Interventions not able to

Table 1. Data collected through selected provider assessments

	RMNCH, HIV, Tuberculosis, Non–communicable diseases		Child health (curative)		Family planning
	SARA	SPA	R–HFA	IMCI–QoC	QIQ
Geographic scope	**Sample or census**	**Sample or census**	**Sample**	**Sample**	**Sample**
Readiness:					
Training	*	X	X	*	
Supervision	*	X	X	X	*
Availability of guidelines/tools	†	X		X	X
Availability of drugs/commodities	X	X	X	X	X
Quality of care:					
Observation of service provision		X	X	X	X
Re–exam				X	
Exit interview with patient/caregiver		X	X	X	X
Competency:					
Case scenarios/vignettes				X	

SARA – Service Availability and Readiness Assessment, SPA – the DHS Program's Service Provision Assessment (SPA), R–HFA – MEASURE Evaluation's Rapid Health Facility Assessments, QIQ – Quick Investigation of Quality, IMCI QoC – Integrated Management of Childhood Illness – Quality of Care Assessment

*One health worker in facility is asked to report on training/supervision for all health workers in facility.

†Interviewer asks about availability of guidelines/tools but does not ask to see them.

be measured through provider assessments were excluded. These include non–health sector interventions, such as the availability of improved water sources and improved sanitation, and interventions that are limited to use or ownership of a commodity, such as insecticide–treated bednets (ITNs). In addition, many behaviors do not lend themselves to measurement through provider assessments, although interventions seeking to influence the behavior (eg, counselling on breastfeeding practices) may be amenable to measurement in provider assessments.

Feasibility for linking study

For each intervention, we assessed the potential to measure population–based intervention coverage through an approach linking household survey data to provider assessment data, at either the individual level or aggregate community level. This approach makes use of population–based data from a household survey to generate a representative estimate of those in need of the intervention (the denominator). The numerator makes use of both population–based data (to estimate the number of individuals who sought care from a particular provider) and data from service provision assessments to determine whether the provider was "ready" to provide the intervention, information that is not available from a household survey. Feasibility of linking was assessed and categorized as highly feasible/potential/infeasible, by considering whether careseeking data for the intervention could be obtained through a household survey, and whether readiness or quality of care for that intervention could be measured through a provider assessment. Interventions for which either careseeking or readiness/quality of care could not be measured were considered infeasible for a linking study. Interventions for which readiness could not be measured but quality of care might be assessed through observation were considered potential candidates for a linking study. Interventions for which both careseeking and readiness could be measured were considered highly feasible candidates for a linking study. For example, magnesium sulfate for treatment of pre–eclampsia/eclampsia was categorized as highly feasible because careseeking (ANC consultations and facility delivery) is measured via household surveys, and readiness to deliver the intervention (availability of magnesium sulfate, dipstick for urine protein/acetic acid and flame for heating, blood pressure apparatus, and trained staff) is currently collected in provider assessments. On the other hand, treatment of neonatal sepsis with antibiotics was categorized as infeasible, because careseeking for neonatal sepsis is not currently measured in household surveys due to the difficulty in establishing a valid denominator (newborns with signs of sepsis) using a survey questionnaire.

RESULTS

Table 2 presents the 58 included interventions, organized across the continuum of care, and the current data sources for coverage, readiness, and quality of care for each intervention.

Table 2. RMNCH interventions and data sources

Intervention	Mode of delivery	Could household survey establish population in need?	Currently measured in MICS/DHS?	Interventions measured in DHS/MICS	Facility–based interventions		
				Reference period	Currently measured in standard provider assessments?, R (readiness), O (observation), N (no)	Source of provider data, R (readiness), O (observation)	Feasible for linking study
Periconceptional:							
Contraception	Facility, community, outreach	Yes	Yes	3 y/5 y	R, O	SARA (R), SPA (R,O), QIQ (R,O)	Highly feasible
Periconceptional folic acid supplementation	Facility–based	Yes	No		N		Infeasible
Safe abortion services	Facility–based	No	No		N		Infeasible
Post abortion case management	Facility–based	No	No		R		Infeasible
Ectopic pregnancy case management	Facility–based	No	No		N		Infeasible
Antenatal:							
Tetanus toxoid vaccine for pregnant women	Facility and outreach	Yes	Yes	2–5 y	R, O	SARA (R), SPA (R,O), R–HFA (R)	Highly feasible
Intermittent preventive treatment of malaria in pregnancy	Facility–based	Yes	Yes	2–5 y	R, O	SARA (R), SPA (R,O), R–HFA (R)	Highly feasible
Syphilis detection and treatment in pregnancy	Facility–based	Yes	No		R, O	SARA (R), SPA (R,O), R–HFA (R)	Highly feasible
Calcium supplementation for prevention and treatment of eclampsia and pre–eclampsia	Facility–based	Yes	No		N		Potential
Multiple micronutrient supplementation	Facility–based	Yes	No		N		Potential
Balanced energy supplementation	Facility and outreach	Yes	No		N		Infeasible
Detection and management of diabetes in pregnancy	Facility–based	No	No		R	SARA (R), SPA (R)	Highly feasible
Pregnant women sleeping under an insecticide–treated bednet	Behavior	Yes	Yes	Last night			
Treatment of malaria in pregnant women	Facility–based	No	No		R	SARA (R), SPA (R)	Infeasible
Management of pre–eclampsia with magnesium sulfate	Facility–based	No	No		R	SARA (R), SPA (R)	Highly feasible
Detection and management of fetal growth restriction	Facility–based	No	No		N		Infeasible
Anti–retroviral therapy for pregnant women	Facility–based	No	No		R	SARA (R), SPA (R)	Highly feasible
Prevention of mother to child transmission of HIV	Facility–based	No	No		R	SARA (R), SPA (R)	Highly feasible
Intrapartum:							
Skilled birth attendant	Facility, community (Service contact)	Yes	Yes	2–5 y	R	SARA (R), SPA (R)	Highly feasible
Clean birth practices	Facility, community	Yes	No		R	SARA (R), SPA (R)	Highly feasible
Immediate assessment and stimulation for newborns	Facility, community	Partial	No		R	SARA (R), SPA (R)	Potential
Neonatal resuscitation	Facility–based	No	No		R	SARA (R), SPA (R), R–HFA (R)	Highly feasible
Antibiotics for preterm premature rupture of membranes	Facility–based	No	No		R	SARA (R), SPA (R)	Highly feasible
Antenatal corticosteroids for preterm labor	Facility–based	No	No		R	SARA (R), SPA (R)	Highly feasible*
Magnesium sulfate for eclampsia	Facility–based	No	No		R	SARA (R), SPA (R)	Highly feasible
Active management of the third stage of labor	Facility–based	Yes	No		R	SARA (R), SPA (R), R–HFA (R)	Potential
Induction of labor for 41+ weeks	Facility–based	No	No		N		Potential
Postnatal:							
Postnatal visit for moms and for babies	Facility, community (service contact)	Yes	Yes	2–5 y	N		Highly feasible
Immediate initiation of breastfeeding	Behavior occurring in facility or community	Yes	Yes	2–5 y	N		Potential
Thermal care	Facility, community	Yes	Not currently; likely in future		R	SPA (R)	Potential

Table 2. Continued

Intervention	Mode of delivery	Could household survey establish population in need?	Currently measured in MICS/DHS?	Interventions measured in DHS/MICS	Facility–based interventions		
				Reference period	Currently measured in standard provider assessments?, R (readiness), O (observation), N (no)	Source of provider data, R (readiness), O (observation)	Feasible for linking study
Clorhexidine for umbilical cord cleansing	Facility, community	Yes	No		R	SARA (R), SPA (R)	Highly feasible
Kangaroo mother care	Facility, community	No	No		R	SPA (R)	Potential
Feeding:							
Breastfeeding	Behavior	Yes	Yes	24 h			
Complementary feeding	Behavior	Yes	Yes	24 h			
Under–five:							
Vitamin A supplementation	Facility, outreach	Yes	Yes	6 mo	R	SARA (R), SPA (R)	Infeasible
Polio vaccine	Facility, outreach	Yes	Yes	5 y	R	SARA (R), SPA (R)	Infeasible
BCG vaccine	Facility–based	Yes	Yes	5 y	R	SARA (R), SPA (R)	Infeasible
Meningitis vaccine	Facility, outreach	Yes	No		N		Infeasible
Pentavalent3/DPT3 vaccine	Facility–based	Yes	Yes	5 y	R	SARA (R), SPA (R), R–HFA (R)	Infeasible
Pneumococcal vaccine	Facility–based	Yes	Yes	5 y	R	SARA (R)	Infeasible
Rotavirus vaccine	Facility–based	Yes	Yes	5 y	R	SARA (R)	Infeasible
Measles vaccine	Facility, outreach	Yes	Yes	5 y	R	SARA (R), SPA (R), R–HFA (R)	Infeasible
Antibiotics for neonatal sepsis	Facility, community	No	No		R	SARA (R), SPA (R), R–HFA (R)	Infeasible
Oral rehydration solution for diarrhea	Facility, community	Yes	Yes	2 weeks	R, O	SARA (R), SPA (R,O), IMCI (R,O), R–HFA (R,O)	Highly feasible†
Zinc for diarrhea	Facility, community	Yes	Yes	2 weeks	R, O	SARA (R), SPA (R,O), IMCI (R,O)	Highly feasible
Antibiotics for dysentery	Facility–based	No	No		R, O	SARA (R), SPA (R,O), IMCI (R,O), R–HFA (R,O)	Highly feasible
Antibiotics for suspected pneumonia	Facility, community	No	Yes	2 weeks	R, O	SARA (R), SPA (R,O), IMCI (R,O), R–HFA (R,O)	Highly feasible
Artemisinin combination therapies for malaria	Facility, community	No	Yes	2 weeks	R, O	SARA (R), SPA (R,O), IMCI (R,O), R–HFA (R,O)	Highly feasible
Vitamin A treatment for measles	Facility–based	No	No		R, O	SARA (R), SPA (R,O), IMCI (R,O), R–HFA (R)	Infeasible
Management of severe malnutrition	Facility–based	No	No		N		Infeasible
Cotrimoxazole for HIV	Facility–based	No	No		R	SARA (R), SPA (R)	Infeasible
Paediatric anti–retroviral therapy for HIV	Facility–based	No	No		R	SARA (R), SPA (R)	Infeasible
Environmental:							
Use of improved water source	Behavior	Yes	Yes	NA			
Use of improved sanitation	Behavior	Yes	Yes	NA			
Hygienic disposal of children's stool	Behavior	Yes	Yes	Last stool			
Handwashing	Behavior	Yes	No				
Insecticide–treated bednet ownership	Outreach	Yes	Yes	NA			
Insecticide–treated bednet use	Behavior	Yes	Yes	Last night			

SARA – Service Availability and Readiness Assessment, SPA – the DHS Program's Service Provision Assessment (SPA), R–HFA – MEASURE Evaluation's Rapid Health Facility Assessments, QIQ – Quick Investigation of Quality, IMCI – WHO integrated management of childhood illness (previously the IMCI–MCE Health Facility Survey)

*A recent study has called into question the benefits of antenatal corticosteroids in low– and middle–income countries [12].

†In settings where ORS is primarily distributed through health facilities and community health workers.

Measurement of intervention coverage through household surveys

Twenty–four, or fewer than half, of the included interventions are currently measured through regular household surveys (DHS or MICS). Of those interventions not measured through household surveys, all but one (handwashing) are delivered at health facilities; five can also be delivered at community level and two via outreach. Two of the measured interventions are proxies for intervention coverage and actually measure careseeking, ie, skilled birth attendance and postnatal visits, rather than interventions. Many of the measured interventions fall in the under–five and environmental categories, with 11 of 18 under–five interventions and five of six environmental interventions measured in MICS and DHS. Within the under–five category, however, there are gaps with respect to measuring treatment of malnutrition and neonatal infections. Along the continuum of care, the intrapartum period stands out as the highest risk period for women and babies, and yet none of the included interventions for this period is measured in surveys beyond service contacts. Similarly, a relatively low proportion of antenatal (two of 13) and periconceptional (one of five) interventions are measured through MICS and DHS.

Measurement of readiness and quality of care

Of the 49 interventions that can be delivered at a health facility, provider assessments currently measure readiness for 27 interventions, and readiness and observation–based quality of care for 10 interventions. Those interventions not currently addressed by provider assessments are primarily periconceptional and antenatal in nature (for example, safe abortion services, calcium supplementation, and detection and management of fetal growth restriction). The WHO's SARA and the DHS Program's SPA are the main sources of these data. These two assessments provide data for most of the same interventions. SPAs provide a more complete assessment of health worker training and supervision, as well as the quality of services.

Feasibility of measuring coverage through linked provider assessments and household surveys

Estimating intervention coverage using a linked approach requires the ability to measure careseeking through a population–based household survey and provider readiness to deliver the intervention (or quality of delivery of the intervention) through a health provider assessment. These two sources of information then must be linked, either by matching each individual in the household survey to a particular facility, or by associating everyone in the household survey within a catchment area to a particular facility. We estimate that a linking approach would be highly feasible for 22 interventions, 13 of which are not currently measured in household surveys – five antenatal, six intrapartum, one postnatal, and one under–five intervention. For another five intrapartum and postnatal indicators, a linking approach might be feasible if observation–based provider assessments were used.

DISCUSSION

Given the increasing global attention to accountability for RMNCH and awareness of the importance of intervention coverage to achieve mortality reductions, there is a critical need to measure population coverage of life–saving RMNCH interventions at national scale and on a regular basis. This review sought to map out which interventions are currently measured, and by what means, in order to identify gaps in current approaches to coverage measurement, and to assess the potential for using a new approach linking household surveys and provider assessments to provide estimates of intervention coverage.

A positive finding of this review is that many interventions targeted to children aged 1–59 months are currently measured through large, nationally representative household surveys, as are many environmental interventions. Beyond child health and environmental interventions, however, we found that many lifesaving interventions in the periconceptional, antenatal, intrapartum, and postnatal periods are not currently measured through population–based household surveys. Although some of these interventions may be measured through routine or program data, such data often lack an appropriate denominator and have issues of data quality and completeness. However, we also found that many antenatal and intrapartum interventions are currently measured through provider assessments and would be good candidates for measurement through an approach linking household surveys to provider assessments.

Gaps in coverage measurement

In general, we found that household surveys are not good sources of coverage data for interventions that require caregiver or respondent knowledge of specific clinical details such as a diagnosis. The exception

is conditions for which biomarkers are available. Although new biomarker tests are increasingly available, their use in large–scale surveys is restricted to a few indicators and, where they are available, their use can be complicated and expensive. Household surveys are generally well–suited for measuring preventive interventions and assessing careseeking based on symptoms that can easily be recognized and recalled by mothers. There is a clear measurement gap for interventions delivered during pregnancy and around the time of birth. Household surveys primarily measure careseeking for these periods, and therefore cannot currently be used to track progress in the coverage of most reproductive, maternal, and neonatal interventions. Moreover, many of these interventions are not appropriate for measurement through household surveys, because they require a diagnosis, such as pre–eclampsia or preterm premature rupture of membranes, which cannot be readily established through a survey questionnaire. Household surveys are also not suited to measuring coverage of interventions needed by very small numbers of individuals (such as antibiotics for preterm premature rupture of membranes), as household surveys typically cannot achieve adequate sample sizes to provide precise coverage estimates, for these interventions. This gap is of particular concern given the importance of the period around and immediately after birth for the health of mothers and babies: most maternal and newborn deaths occur during childbirth and in the day following birth [13], and neonatal deaths represent a growing proportion of under–five deaths [14]. Tracking the coverage of interventions that protect against common causes of maternal and neonatal deaths is thus critical to ensuring progress in RMNCH, and is not possible at present.

Another important gap is the lack of data on the accuracy [3], precision, and reliability of the coverage data collected through household surveys. Where data on indicator validity exist, they suggest that although household surveys can provide accurate coverage measures for some interventions, such as treatment of fever with an ACT [15], other interventions such as antibiotics for pneumonia are not well measured through such surveys [16]. The question of whether coverage measurements are reliable over time and across countries is of central importance if survey data are to be used to track progress in coverage of RMNCH interventions. There is an urgent need for research to better understand which health interventions household surveys can provide accurate, precise, and reliable population–based coverage measures, and for which interventions alternative measurement approaches should be explored. A few recent studies have explored the validity of a range of coverage measures for the intrapartum and immediate postnatal period with mixed results [17]. A clear alternative to measuring careseeking (ie, skilled birth attendance) has not yet emerged for the intrapartum period.

Limitations

This review has a number of limitations. Our list of interventions was based on those in the Global Investment Framework for Women's and Children's Health, and included only interventions with published effectiveness estimates (see **Appendix S1** in **Online Supplementary Document**). However, there may be interventions, particularly emerging interventions for which the body of evidence is still developing, that have been omitted. As new interventions emerge over time, there will be an ongoing need to consider whether and how to measure their coverage.

Our process for assessing the feasibility of using a linking approach to estimate the coverage of each intervention was somewhat subjective. Although we attempted to establish clear criteria for each level of feasibility, it is possible that another group might come to somewhat different conclusions. There are ongoing efforts to implement the linking approach using existing and new data. When complete, these studies will provide additional information about the feasibility of linking for various interventions.

Finally, we note that household and provider surveys and routine data continue to evolve. This review provides a snapshot of the gaps and opportunities at a particular point in time. We expect that some of the gaps identified here will be filled over time as data collection instruments are revised and routine health information systems improve.

Research and practice agendas

Providing valid, population–based estimates of coverage for RMNCH interventions at national and sub–national levels is essential to achieving reductions in maternal, newborn, and child deaths and stillbirths, and must be a priority for the RMNCH research and practice community. We recommend three parallel streams of action to improve the availability and quality of data on intervention coverage for RMNCH.

Action stream 1: household surveys

Household surveys should continue to be used as a source of coverage data for those indicators that can be measured through a survey questionnaire. Efforts to validate survey–based measures of RMNCH in-

tervention coverage must continue and must include assessments of the reliability of coverage measurements over time. The results of these efforts should inform future revisions of MICS and DHS survey questionnaires. Where the evidence indicates that surveys do not provide accurate, precise, or reliable measures of intervention coverage, alternative measurement approaches should be explored.

Action stream 2: alternative measurement approaches for facility–based interventions

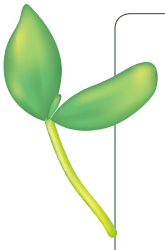
Many of the RMNCH interventions not measured in household surveys, including those that cannot be measured in a household survey because they require a diagnosis, are delivered by a health service provider, and are currently measured in provider assessments. Measurement approaches that link these service provider assessments to data on careseeking collected through household surveys must be pursued urgently. Linking approaches could also be valuable for indicators currently measured in surveys, but for which the validity of the survey–based indicator is questionable, including treatment of childhood illness. Assessments of linking approaches should address the following factors: feasibility and cost at national scale in low– and middle–income countries, as well as the accuracy and reliability of coverage measures produced through this approach. In addition, different approaches to linking household surveys and provider assessments should be tested and compared.

Other approaches to measuring coverage for facility–based interventions, including the use of routine data, may also hold promise and should be assessed using the same considerations as linking approaches (feasibility, cost, accuracy, and reliability).

For approaches that are found to be feasible to implement at reasonable cost and to provide both accurate and reliable measures of intervention coverage, the RMNCH research and practice community should develop guidelines for their implementation and a program to ensure the regular production of coverage measures for these interventions.

Action stream 3: alternative measurement approaches for non–facility–based interventions

For those interventions for which household surveys do not provide accurate or reliable measurements, and which are delivered primarily or entirely outside a facility, a linking a pproach is not feasible and alternative measurement approaches, such as the use of specialized surveys, biomarkers or proxies for the intervention, or modeling, should be explored. This is true for behaviors as well, although a linking approach should be explored for interventions promoting the behavior, such as counselling on breastfeeding practices.



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REFERENCES

1 Stenberg K, Axelson H, Sheehan P, Anderson I, Gülmezoglu AM, Temmerman M, et al. Advancing social and economic development by investing in women's and children's health: a new Global Investment Framework. Lancet. 2014;383:1333-54. Medline:24263249 doi:10.1016/S0140-6736(13)62231-X

2 World Health Organization. Commission on Information and Accountability for Women's and Children's Health. Available: http://www.who.int/woman_child_accountability/about/coia/en/ Accessed: 4 Apr 2017.

3 Bryce J, Arnold F, Blanc A, Hancioglu A, Newby H, Requejo J, et al. Measuring coverage in MNCH: new findings, new strategies, and recommendations for action. PLoS Med. 2013;10:e1001423. Medline:23667340 doi:10.1371/journal.pmed.1001423

4 Eisele TP, Rhoda DA, Cutts FT, Keating J, Ren R, Barros AJ, et al. Measuring coverage in MNCH: total survey error and the interpretation of intervention coverage estimates from household surveys. PLoS Med. 2013;10:e1001386. Medline:23667331 doi:10.1371/journal.pmed.1001386

5 PLoS Collections. Measuring Coverage in Maternal, Newborn, and Child Health. 2013. Available: http://www.ploscollections.org/measuringcoverageinmnch. Accessed 13 January 2015.

6 Cairncross S, Hunt C, Boisson S, Bostoen K, Curtis V, Fung IC, et al. Water, sanitation and hygiene for the prevention of diarrhoea. Int J Epidemiol. 2010;39 Suppl 1:i193-205. Medline:20348121 doi:10.1093/ije/dyq035

7 International ICF. Demographic and Health Surveys. Available: http://www.dhsprogram.com Accessed: 3 May 2014.

8 UNICEF. Statistics and Monitoring: Multiple Indicator Cluster Survey. Available: http://www.unicef.org/statistics/index_24302.html. Accessed: 3 May 2014.

9 Hancioglu A, Arnold F. Measuring coverage in MNCH: tracking progress in health for women and children using DHS and MICS household surveys. PLoS Med. 2013;10:e1001391. Medline:23667333 doi:10.1371/journal.pmed.1001391

10 Edward A, Matsubiyashi T, Fapohunda B, Becker S. A Comparative Analysis of Select Health Facility Survey Methods Applied in Low and Middle Income Countries [working paper WP–09–11]. Chapel Hill, NC: 2009.

11 Institute for International Programs. Linking Household Surveys and Health Service Assessments: Technical Consultation on Study Design. Baltimore, MD: 2014.

12 Althabe F, Belizán JM, McClure EM, Hemingway–Foday J, Berrueta M, Mazzoni A, et al. A population–based, multifaceted strategy to implement antenatal corticosteroid treatment versus standard care for the reduction of neonatal mortality due to preterm birth in low–income and middle–income countries: the ACT cluster–randomised trial. Lancet. 2015;385:629-39. Medline:25458726 doi:10.1016/S0140-6736(14)61651-2

13 Lawn JE, Blencowe H, Oza S, You D, Lee AC, Waiswa P, et al. Every Newborn: progress, priorities, and potential beyond survival. Lancet. 2014;384:189-205. Medline:24853593 doi:10.1016/S0140-6736(14)60496-7

14 Liu L, Oza S, Hogan D, Perin J, Rudan I, Lawn JE, et al. Global, regional, and national causes of child mortality in 2000–13, with projections to inform post–2015 priorities: an updated systematic analysis. Lancet. 2015;385:430-40. Medline:25280870 doi:10.1016/S0140-6736(14)61698-6

15 Eisele TP, Silumbe K, Yukich J, Hamainza B, Keating J, Bennett A, et al. Measuring coverage in MNCH: accuracy of measuring diagnosis and treatment of childhood malaria from household surveys in Zambia. PLoS Med. 2013;10:e1001417. Medline:23667337 doi:10.1371/journal.pmed.1001417

16 Hazir T, Begum K, El Arifeen S, Khan AM, Huque MH, Kazmi N, et al. Measuring coverage in MNCH: a prospective validation study in Pakistan and Bangladesh on measuring correct treatment of childhood pneumonia. PLoS Med. 2013;10:e1001422. Medline:23667339 doi:10.1371/journal.pmed.1001422

17 Stanton CK, Rawlins B, Drake M, Dos Anjos M, Cantor D, Chongo L, et al. Measuring coverage in MNCH: testing the validity of women's self–report of key maternal and newborn health interventions during the peripartum period in Mozambique. PLoS One. 2013;8:e60694. Medline:23667427 doi:10.1371/journal.pone.0060694

Electronic supplementary material:
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Comprehensive review of the evidence regarding the effectiveness of community–based primary health care in improving maternal, neonatal and child health: 1. rationale, methods and database description

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Background Community–based primary health care (CBPHC) is an approach used by health programs to extend preventive and curative health services beyond health facilities into communities and even down to households. Evidence of the effectiveness of CBPHC in improving maternal, neonatal and child health (MNCH) has been summarized by others, but our review gives gives particular attention to not only the effectiveness of specific interventions but also their delivery strategies at the community level along with their equity effects. This is the first article in a series that summarizes and analyzes the assessments of programs, projects, and research studies (referred to collectively as projects) that used CBPHC to improve MNCH in low– and middle–income countries. The review addresses the following questions: (1) What kinds of projects were implemented? (2) What were the outcomes of these projects? (3) What kinds of implementation strategies were used? (4) What are the implications of these findings?

Methods 12 166 reports were identified through a search of articles in the National Library of Medicine database (PubMed). In addition, reports in the gray literature (available online but not published in a peer–reviewed journal) were also reviewed. Reports that describe the implementation of one or more community–based interventions or an integrated project in which an assessment of the effectiveness of the project was carried out qualified for inclusion in the review. Outcome measures that qualified for inclusion in the review were population–based indicators that defined some aspect of health status: changes in population coverage of evidence–based interventions or changes in serious morbidity, in nutritional status, or in mortality.

Results 700 assessments qualified for inclusion in the review. Two independent reviewers completed a data extraction form for each assessment. A third reviewer compared the two data extraction forms and resolved any differences. The maternal interventions assessed concerned education about warning signs of pregnancy and safe delivery; promotion and/or provision of antenatal care; promotion and/or provision of safe delivery by a trained birth attendant, screening and treatment for HIV infection and other maternal infections; family planning, and; HIV prevention and treatment. The neonatal and child health interventions that were assessed concerned promotion or provision of good nutrition and immunizations; promotion of healthy household behaviors and appropriate utilization of health services, diagnosis and treatment of acute neonatal and child illness; and provision and/or promotion of safe water, sanitation and hygiene. Two–thirds of assessments (63.0%) were for projects implementing three or fewer interventions in relatively small populations for relatively brief periods; half of the assessments involved fewer than 5000 women or children, and 62.9% of the assessments were for projects lasting less than 3 years. One–quarter (26.6%) of the projects were from three countries in South Asia: India, Bangladesh and Nepal. The number of reports has grown markedly during the past decade. A small number of funders supported most of the assessments, led by the United States Agency for International Development. The reviewers judged the methodology for 90% of the assessments to be adequate.

Conclusions The evidence regarding the effectiveness of community–based interventions to improve the health of mothers, neonates, and children younger than 5 years of age is growing rapidly. The database created for this review serves as the basis for a series of articles that follow this one on the effectiveness of CBPHC in improving MNCH published in the Journal of Global Health. These findings, guide this review, that are included as the last paper in this series, will help to provide the rationale for building stronger community–based platforms for delivering evidence–based interventions in high–mortality, resource–constrained settings.

The evidence that community–based interventions can improve maternal, neonatal and child health (MNCH) has been steadily growing over the past several decades [1–3]. Nonetheless, community–based primary health care (CBPHC) as an approach for engaging communities and delivering health interventions to communities and even down to each household remains an underdeveloped component of health systems in most resource–constrained settings. Except for immunizations and vitamin A supplementation, population coverage levels of evidence–based MNCH interventions in the countries with 97% of the world's maternal, neonatal and child deaths remains around 50% or less [4]. The evidence regarding the effectiveness of individual interventions provided at the community level continues to grow. We now stand in a moment of time in which the era of the United Nations' Millennium Development Goals has ended (2000–2015) and the era of the Sustainable Development Goals has begun (2015–2030). Thus, now is an opportune time to take stock of the evidence regarding the effectiveness of community–based approaches in improving MNCH and the approaches that have been used to achieve effectiveness.

Even though major gains have been made around the world in reducing maternal, neonatal, and child mortality (MNCH), 8.8 million maternal deaths, stillbirths, neonatal deaths, and deaths of children 1–59 months of age occur each year, mostly from readily preventable or treatable conditions [5]. Only four of the 75 countries with 97% of the world's maternal, perinatal, neonatal and child deaths were able to achieve both Millennium Development Goal (MDG) 4 (which called for a two–thirds reduction in under–5 mortality by the year 2015 compared to 1990 levels) and MDG 5 (which called for a three–quarters reduction of maternal mortality) [6]. One of the important reasons for this disappointing result was the failure to implement and scale up evidence–based community–based interventions.

To date, there has been limited attention given to systematically accumulating and analyzing the broad range of evidence regarding the effectiveness of CBPHC in improving MNCH, although excellent summaries of portions of this evidence do exist [1–3,7–17]. In addition, there appears to be a rebirth of global primary health care more generally, especially in light of the upcoming 40th anniversary of the signing of the Declaration of Alma–Ata at the International Conference on Primary Health Care at Alma–Ata, Kazakhstan in 1978, sponsored by the World Health Organization and UNICEF [18]. This article is the first of a series that highlights the findings of a comprehensive review and analysis of this evidence in low– and middle–income countries (LMICs).

The context

The global primary health care movement began in the 1960s following the recognition that hospitals were not improving the health of the populations they were serving. At that time, a series of surveys of populations served by hospital–oriented Christian medical mission programs around the world demonstrated that the people who had easy access to and used the hospital regularly were no healthier than people who did not [19]. This led to the formation of the Christian Medical Commission (CMC) of the World Council of Churches, which provided a framework and a forum for new thinking about how programs can best improve the health of people in high–mortality, resource–constrained settings. In the 1970s, these discussions involved global health visionaries of their time, including Dame Nita Barrow, Jack Bryant, Carl Taylor, and William Foege, all of whom were members of the CMC, and high–level officials at the World Health Organization (WHO), including Halfdan Mahler, then Director–General, and Ken Newell, Director of Strengthening of Health Services at WHO [20,21]. One of the fruits of these discussions was the seminal WHO publication, *Health by the People* [22]. This book described a number of successful pioneering CBPHC projects around the world and laid the groundwork for the 1978 International Conference on Primary Health Care at Alma–Ata, Kazakhstan and the now renowned Declaration of Alma–Ata, which called for Health for All by the Year 2000 through primary health care [21,23].

Article V of the 1978 Declaration of Alma–Ata states the following [24]:

"*Governments have a responsibility for the health of their people that can be fulfilled only by the provision of adequate health and social measures. A main social target of governments, international organizations and the whole world community in the coming decades should be the attainment by all peoples of the world by the year 2000 of a level of health that will permit them to lead a socially and economically productive life. Primary health care is the key to attaining this target as part of development in the spirit of social justice.*"

The broad concept of primary health care articulated in this Declaration was much more than the delivery of medical services at primary health care centers. Primary health care, as defined by the Declaration of Alma–Ata, involves providing preventive, promotive, curative, and rehabilitative health care services as close to the community as possible by members of a health team, including community health work-

ers and traditional practitioners, and it broadened the concept even further by calling for primary health care to also address the primary causes of ill–health through inter–sectoral collaboration, community participation, and reduction of inequities.

Over the past three decades since the Declaration of Alma–Ata, major progress has been made in reducing child and maternal mortality throughout the world. The number of children dying before 5 years of age has declined from 18.9 million in 1960 [25] to 5.9 million in 2015 [26] despite the fact that the number of births each year has increased from 96 million in 1960 [25] to 139 million in 2015 [27]. The global under–5 mortality rate has declined from 148 per 1000 live births in 1970 [25] to 43 in 2015 [26]. Over the past 25 years, the global under–5 mortality rate globally has fallen by 53% [26], far less than the 67% required to reach the Millennium Development Goal for 2015. Reductions in maternal mortality have also been important but more gradual. The number of maternal deaths declined from 532 000 in 1990 to 303 000 in 2015 [28], and the global maternal mortality ratio fell by 44% during this period [28], far less than the 75% required to achieve the Millennium Development Goal.

Although evidence about the effectiveness of specific community–based interventions is generally well–documented, evidence about the total range of CBPHC interventions for MNCH, their effectiveness, how these interventions are actually delivered in practice (particularly in combination with other interventions), and the conditions that appear to be important for achieving success are less summarized. This is the heart of what our review is about.

Our review begins with the premises that (1) further strengthening CBPHC by expanding the population coverage of evidence–based interventions has the potential to accelerate progress in ending preventable child and maternal deaths, and (2) CBPHC has the potential for providing an entry point for establishing a more comprehensive primary health care system in resource–constrained settings that can enable health systems to more effectively improve population health and, at the same time, more effectively meet the needs and expectations of local people for medical care.

There is now, more than ever, a need for evaluation of what works and for "systematic sharing of good practices and greater sharing of new information" [29]. As an editorial in *The Lancet* [30] observed:

"Evaluation must now become the top priority in global health. Currently, it is only an afterthought. A massive scale–up in global health investments during the past decade has not been matched by an equal commitment to evaluation.… [Evaluation] will not only sustain interest in global health. It will improve quality of decision making, enhance efficiency, and build capacity for understanding why some programmes work and others do not. Evaluation matters. Evaluation is science."

This series provides an opportunity to summarize, review and analyze the evidence regarding the effectiveness of CBPHC in improving the health of mothers and their children, to draw conclusions regarding the findings from this review, and to suggest next steps in research, policy and program implementation.

Background of the review

In the early 1990s, Dr John Wyon (now deceased) and Dr Henry Perry organized panels at the annual meetings of the American Public Health Association (APHA) to highlight the contributions of CBPHC to improving the health of geographically–defined populations. As a result of support and encouragement from the International Health Section at APHA and from APHA staff, a Working Group on CBPHC within the International Health Section was established in 1997. For two decades now, the Working Group has been holding day–long annual workshops on themes related to CBPHC. One of these workshops led to the publication of a book on CBPHC [31]. As the evidence continued to mount regarding the effectiveness of CBPHC in improving health, the Working Group decided that a comprehensive review was needed.

Thus, beginning in 2005, the Working Group created a Task Force for the Review of the Evidence of CBPHC in Improving Child Health, with Henry Perry and Paul Freeman serving as Co–Chairs. What began as a small volunteer effort by Perry and Freeman and others has now, more than a decade later, involved over 150 people and not only APHA but also the World Health Organization, UNICEF, the World Bank, the US Agency for International Development, Future Generations (the NGO where Dr Perry was employed at the outset of the review), and most recently the Gates Foundation.

Following an initial small grant from the World Health Organization in 2006, an Expert Panel was created under the chairmanship of Dr Carl Taylor, then Professor Emeritus of International Health at the Johns Hopkins University (**Table 1**). This group participated in the initial design of the review and then later met face to face at UNICEF Headquarters in 2008 to discuss preliminary findings of the review. Af-

Table 1. Members of the Expert Panel for the Review of the Effectiveness of Community–Based Primary Health Care in Improving Maternal, Neonatal and Child Health

Name	Organizational affiliation	Title	Location	Participated in formalization of guidelines for review 2006	Participated in face—to—face meeting of Panel in 2008	Participated in review of final findings (2016)
Raj Arole	Jamkhed Comprehensive Rural Health Project	Director (now deceased)	Jamkhed, India	X		
Shobha Arole	Jamkhed Comprehensive Rural Health Project	Director	Jamkhed, India			X
Rajiv Bahl	World Health Organization	Medical Officer, Child and Adolescent Health and Development Unit	Geneva, Switzerland	X		
Abhay Bang	Society for Education, Action and Research in Community Health (SEARCH)	Director	Gadchiroli, India	X	X	X
Al Bartlett	United States Agency for International Development	Formerly Senior Advisor for Child Survival, USAID; now retired	Washington, DC, USA	X		
Zulfiqar Bhutta	Centre for Global Child Health, Hospital for Sick Children, Toronto, Canada and Center of Excellence in Women and Child Health, the Aga Khan University, Karachi, Pakistan	Professor	Toronto, Canada and Karachi, Pakistan			X
Robert Black*	Bloomberg School of Public Health, Johns Hopkins University	Professor, Department of International Health	Baltimore, MD, USA	X	X	X
Mushtaque Chowdhury	BRAC	Formerly Dean of the James Grant School of Public Health; currently Deputy Director	Dhaka, Bangladesh			X
Anthony Costello	World Health Organization	Formerly Professor, International Perinatal Care Unit, Institute of Child Health, University College, London; currently Director, Department of Maternal, Newborn, Child and Adolescent Health	Geneva, Switzerland	X		
Dan Kaseje	Tropical Institute of Community Health and Development	Director	Kisumu, Kenya	X	X	X
Betty Kirkwood	London School of Hygiene and Tropical Medicine	Public Health Intervention Research Unit, Professor of Epidemiology and International Health	London, England	X		X
Rudolph Knippenberg	UNICEF	Senior Advisor for Health	New York, NY, USA	X	X	
Nazo Kureshy	United States Agency for International Development	Team Leader, Child Survival and Health Grants Program, Bureau for Global Health	Washington, DC, USA		X	X
Claudio Lanata	Instituto de Investigation Nutricional	Senior Researcher	Lima, Peru	X	X	X
Adetokunbo Lucas	Harvard University	Adjunct Professor of International Health	Ibidan, Nigeria	X	X	
James Phillips	Mailman School of Public Health, Columbia University	Professor	New York, NY, USA	X	X	X
Pang Ruyan	School of Public Health, Peking University	Visiting Professor and formerly National Coordinator for China, WHO Global Survey on Maternal and Perinatal Health	Beijing, China	X	X	
David Sanders	School of Public Health, University of Western Cape	Professor and Dean emeritus	Cape Town, South Africa	X	X	
Agnes Soucat	World Health Organization	Formerly Lead Economist, Human Development, Africa Region of the World Bank and currently Director of Health Systems, Governance and Financing of the World Health Organization	Geneva, Switzerland	X		
Carl Taylor†	Bloomberg School of Public Health, Johns Hopkins University	Professor Emeritus, Department of International Health (now deceased)	Baltimore, MD, USA	X	X	
Mary Taylor	Independent consultant	Formerly Senior Program Officer, Community Health Solutions, the Gates Foundation and currently Independent Senior Technical Expert	South Royalton, Vermont, USA	X	X	X
Cesar Victora	Federal University of Pelotas	Professor of Epidemiology	Pelotas, Brazil	X		X
Zonghan Zhu	Capital Institute of Pediatrics and China Advisory Center for Child Health, Beijing; Chinese Preventive Medicine Association	Professor, Capital Institute of Pediatrics and China Advisory Center for Child Health, Beijing, and Chairman of Child Health, Chinese Preventive Medicine Association	Beijing, China	X	X	X

*Chair of the Panel, 2010 to present.

†Chair of the Panel, 2006–2010.

ter Dr Taylor's death in 2010, the Panel reconvened under the leadership of Dr Robert Black, Professor of International Health at Johns Hopkins, and has participated in the final set of recommendations that constitute the final article in this series [32].

When the review began in 2006, the focus was exclusively on child health (that is, the health of children in their first 5 years of life). With support from USAID and the Gates Foundation between 2013 and 2016, it became possible to expand the scope of the review to maternal health. Thus, we have now renamed the overall effort a review of the effectiveness of CBPHC in improving MNCH.

Goals of the review

The goal of this review is to summarize the evidence regarding what can be achieved through community–based approaches to improve MNCH. The health of mothers, neonates and children as a measurable outcome is defined here for our purposes as the level of mortality, serious morbidity, nutritional status, or coverage of proven interventions for mothers, neonates and children in a geographically defined population. The review focuses on interventions and approaches that are carried out beyond the walls of health facilities that serve populations of mothers, neonates and children living in geographically defined areas.

The review consists of an analysis of documents describing research studies, field projects, and programs (collectively referred to in this series as projects) that have assessed the impact of CBPHC on MNCH. Altogether, the findings comprise a comprehensive overview of the global evidence in using CBPHC to improve MNCH. In addition, the review describes the strategies used to deliver community–based interventions and the role of the community and community health workers in implementing these interventions. In addition, the review seeks to understand the context of the projects – where they were implemented and by whom, where the funding came from, for how long, what size of population was served by the project, and what additional contextual factors might have influenced the project outcomes – as well as the methodological quality of the assessment.

The questions which the review seeks to answer are:

- How strong is the evidence that CBPHC can improve MNCH in geographically defined populations and sustain that improvement?
- What specific CBPHC activities improve MNCH?
- What conditions (including those within the local health system) facilitate the effectiveness of CBPHC and what community–based approaches appear to be most effective?
- What characteristics do effective CBPHC activities share?
- What program elements are correlated with improvements in child and maternal health?
- How strong is the evidence that partnerships between communities and health systems are required in order to improve child and maternal health?
- How strong is the evidence that CBPHC can promote equity?
- What general lessons can be drawn from the findings of this review?
- What additional research is needed?
- How can successful community–based approaches for improving MNCH be scaled up to regional and national levels within the context of serious financial and human resource constraints?
- What are the implications for local, national and global health policy, for program implementation, and for donors?

METHODS

The Task Force and the Expert Panel agreed on the following definition of CBPHC:

CBPHC is a process through which health programs and communities work together to improve health and control disease. CBPHC includes the promotion of key behaviors at the household level as well as the provision of health care and health services outside of health facilities at the community level. CBPHC can (and of course should) connect to existing health services, health programs, and health care provided at static facilities (including health centers and hospitals) and be closely integrated with them.

CBPHC involves improving the health of a geographically defined population through outreach outside of health facilities. CBPHC does not include health care provided at a health facility unless there is community involvement and associated services beyond the facility.

CBPHC also includes multi–sectoral approaches to health improvement beyond the provision of health services per se, including programs that seek to improve (directly or indirectly) education, income, nutrition, living standards, and empowerment.

CBPHC programs may or may not collaborate with governmental or private health care programs; they may be comprehensive in scope, highly selective, or somewhere in between; and they may or may not be part of a program which includes the provision of services at health facilities.

CBPHC includes the following three different types of interventions:

- Health communication with individuals, families and communities;
- Social mobilization and community involvement for planning, delivering, evaluating and using health services; and
- Provision of health care in the community, including preventive services (eg, immunizations) or curative services (eg, community–based treatment of pneumonia).

Types of assessments of maternal, neonatal and child health interventions qualifying for review

The Task Force sought documents that described community–based programs, projects and research studies that carried out assessments of changes in MNCH indicators in such a way that any changes observed could reasonably be attributed to CBPHC program interventions. At least one of the following outcome indicators was required to be present in order for the assessment to be included in the review.

Maternal health

- Change in the population coverage of one or more evidence–based interventions (utilization of antenatal care, delivery by a trained attendant, delivery in a health facility, clean delivery, and postpartum care)
- Change in nutritional status
- Change in the incidence or in the outcome of serious, life–threatening morbidity (such as pre–eclampsia, eclampsia, sepsis, hemorrhage); or,
- Change in mortality.

Neonatal and child health

- Change in the population coverage of one or more evidence–based interventions (clean delivery; appropriate care during the neonatal period; appropriate infant and young child feeding, including appropriate breastfeeding; immunizations; vitamin A supplementation; appropriate prevention of malaria with insecticide–treated bed nets and intermittent preventive therapy; appropriate hand washing; appropriate treatment of drinking water, appropriate sanitation; appropriate treatment of pneumonia, diarrhea and malaria;
- Change in nutritional status (as measured by anthropometry, anemia, or assessment of micro–nutrient deficiency);
- Change in the incidence or in the outcome of serious but non–life–threatening morbidity (such as trachoma, which can result in blindness);
- Change in the incidence or in the outcome of serious, life–threatening morbidity (such as pneumonia, diarrhea, malaria, and low–birth weight); or,
- Change in mortality (perinatal, neonatal, infant, 1–4–year, and under–5 mortality);

In addition, the review included an analysis of available documentation concerning the degree to which improvements in child health obtained by CBPHC approaches were equitable.

Document retrieval

The principal inclusion criteria for the literature review were: (1) a report describing the CBPHC program for a defined geographic population and (2) a description of the findings of an assessment of the project's effect on maternal, neonatal or child health as defined above. The focus was on the effectiveness of program interventions on the health of all mothers and/or children in a geographically defined area, although

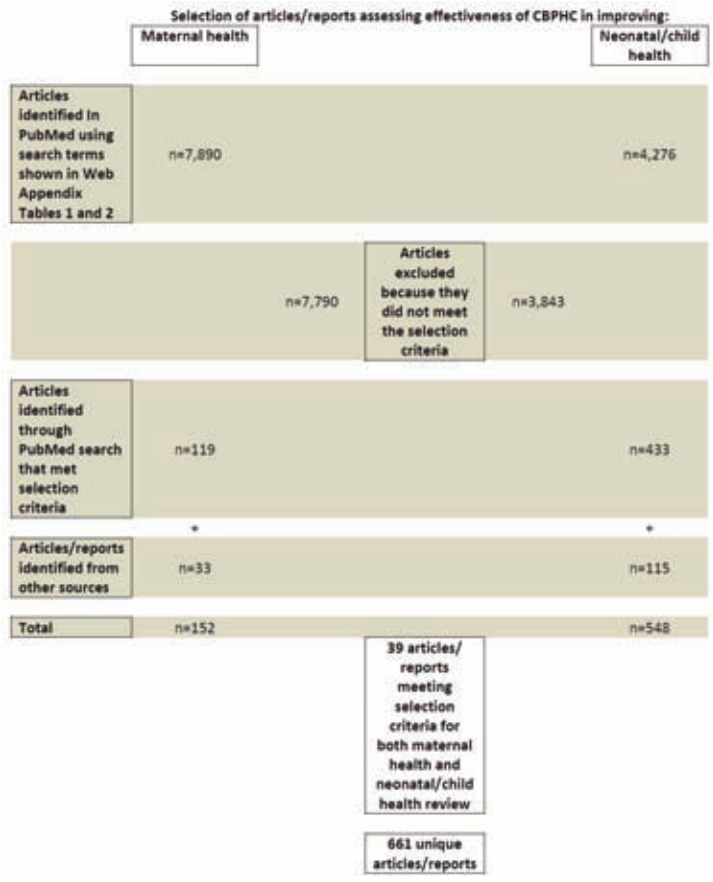

Figure 1. Selection process of assessments of the effectiveness of community-based primary health care (CBPHC).

in some cases (eg, in studies of maternal–to–child HIV transmission), the focus was on a subset of mothers and their children in a geographically defined area.

Key terms for "maternal health," "child health," "community health," and "developing countries" and related terms were identified to create a search query (see Tables S1 and S2 in **Online Supplementary Document**). The United States National Library of Medicine's PubMed database was searched periodically up until 31 December 2015 using these two queries, yielding 7890 articles on maternal health and 4276 articles on neonatal or child health (**Figure 1**). The articles were screened separately by two members of the study team. Assessments of the effectiveness of CBPHC in which the outcomes were improvements in neurological, emotional or psychological development of children were not included unless the reports also included one or more of the other neonatal or child health outcome measures mentioned above.

In addition to the PubMed search, broadcasts were sent out on widely used global health listservs, including those of the Global Health Council, the American Public Health Association, the Collaboration and Resources Group for Child Health (the CORE Group), the World Federation of Public Health Associations, and the Association of Schools of Public Health asking for information about documents, reports, and published articles which might qualify for the review. Finally, the Task Force contacted knowledgeable persons in the field for their suggestions for documents to be included, including members of the Expert Panel. Documents not published in peer–reviewed scientific journals were included if they met the criteria for review, if they provided an adequate description of the intervention, and if they had a satisfactory form of evaluation. A total of 152 assessments met the criteria for the maternal health review and 548 for the neonatal/child health review (**Figure 1**).

Table S3 in **Online Supplementary Document** contains a bibliography with the references associated with these 700 assessments. The bibliography also indicates which references were in the maternal health review, in the child health review (and which of these were included in the analyses for neonatal health and child health), and the equity review. There are a number of cases in which a single assessment in our database is derived from more than one document. All of these references are included in the bibliography. Thus, when in **Figure 1** above we refer to the number of articles/reports, there are a small number of cases in which we have combined the various articles/reports associated with a single assessment and counted this as only one assessment.

Of the 33 maternal health assessments and the 115 neonatal/child health assessments included in the review that were not identified through PubMed, most (16 and 80, respectively) were project evaluations of child survival projects funded by the USAID Child Survival and Health Grants Program and implemented by US–based non–governmental organizations. These are listed separately in Table S4 in **Online Supplementary Document.** Other assessments that were not identified through PubMed were evaluations from other sources, books, or book chapters.

The document review process

Two data extraction forms were prepared through an iterative process. The extraction form to be used for child health assessments and the form for maternal health assessments were identical except for the interventions carried out. These forms are contained in Appendices S5 and S6 in **Online Supplementary**

Document. Both forms were developed with the purpose of extracting all possible information available regarding how the interventions were implemented at the community level and what the role of the community was in implementation.

Two independent reviewers each completed a Data Extraction Form for each assessment that qualified for the review. A third reviewer provided quality control and resolved any difference observed in the two reviews, and the final summative review was transferred to an EPI INFO database (version 3.5.4) (Epi Info, US Centers for Disease Control and Prevention, Atlanta, Georgia, USA). The names of the reviewers, many of whom worked on a volunteer basis, are shown in the acknowledgment section; their names and professional titles are contained in Table S7 in **Online Supplementary Document**.

Comment on terminology used

The assessments included in our review were carried out for field studies, projects, and programs that employed one or more CBPHC interventions for improving maternal, neonatal and/or child health. This is a heterogeneous group of assessments in the sense that they range from (1) research reports describing the efficacy of single interventions over a short period of time in a highly supervised and well–supported field setting to (2) assessments of programs which provided a comprehensive array of health and development programs over a long period of time in more typical field setting. When referring to this group of community–level activities as a whole, they should properly be referred to as "research studies/field projects/programs" but for practicality's sake we will refer to them throughout this series simply as "projects," and the evaluations of their effectiveness as "assessments."

Database description

An electronic database describing 700 assessments of the effectiveness of CBPHC in improving MNCH was queried using EPI INFO version 3.5.4 and STATA version 14 (StatCorp LLC, College Station, Texas, USA). For the purpose of this review, the 39 assessments with both maternal and child health outcomes have been counted as separate assessments in our analysis. Overall, 78.8% of assessments are scientific articles published in peer–reviewed journals, 4.0% are some other type of publication (mostly books or reports not available on the internet), and 12.7% are either from the gray literature (available on the internet) or unpublished project evaluations.

Over three–fourths (78.4%) of the assessments included in our review were carried out in rural settings at least in part, while 16.9% and 11.1% were carried out exclusively in an urban or peri–urban setting, respectively.

Among the 700 assessments in our data set, a small proportion contained data from more than one country. Thus, altogether, 786 country–specific assessments were identified. India, Bangladesh, and Nepal had the largest number of assessments (86, 77, and 47, respectively). 49.0% of the country–specific assessments came from Africa WHO Region, 28.5% from the South–East Asia Region, and 9.7% from the Americas (**Table 2** and Table S8 in **Online Supplementary Document**). 8.6% of reports assessed interventions in a single community, 38.1% in a set of communities not encompassing an entire health district (or sub–province), 37.5% at the district (or sub–province) level, 7.5% at the provincial/state level, 3.7% at a national level, and 3.2% at a multinational level.

The implementing and facilitating organizations for these projects were primarily private entities (NGOs, universities and research organizations), often working with governments at the national, provincial, or local level (**Table 3**). While communities were — by definition — involved in all of these projects, in only 4.3% of assessments were local communities the only identified implementers. Those who actually implemented projects at the local level were community health workers (CHWs), local community members, research workers, and government health staff.

Half (49.3%) of the assessments are of projects serving 5000 or fewer women and children. 18.2% of the assessments are based on data derived from projects reaching more than 25000 women and children. 61.9% of the projects had begun since 2000. Almost half (46.3%) of projects were less than 2 years in duration and almost two–thirds (62.9%) were implemented for less than 3 years. Among the neonatal and child health assessments, 51.6% were of only one intervention, and 87.4% were of four or fewer interventions. On the other hand, among the maternal health assessments three–quarters (75.7%) included five or more interventions.

Our review includes 16 assessments of projects that were completed before 1980. The earliest report describes the health impact of an integrated primary health care project in South Africa led by Sidney Kark

Table 2. Number of assessments of the effectiveness of community–based primary health care in improving maternal, neonatal and child health by region and the countries with the greatest number of assessments

WHO Region	Number	% (n = 786)*	Country	Number	% (n = 786)*
Africa	385	49.0%	India	86	10.9
South–East Asia	224	28.5%	Bangladesh	77	9.8
Americas	76	9.7%	Nepal	47	6.0
Eastern Mediterranean	61	7.8%	Ghana	36	4.6
Western Pacific	37	4.7%	Pakistan	35	4.5
Europe	4	0.5%	Uganda	34	4.3
Total	786*	100.0%	Tanzania	30	3.8
			Ethiopia	28	3.6
			Kenya	27	3.4
			Malawi	19	2.4

*The total number of countries listed here exceeds the number of assessments because some assessments were conducted in multiple countries.

Table 3. Implementers of projects for improving MNCH

	Number	% (n = 700)
Facilitating and/or stakeholder organization:		
State or national government	424	60.6
International NGO	281	40.1
Private organization/university/research organization	254	36.3
Local government	243	34.7
Local NGO	125	17.9
National NGO	85	12.1
Faith–based organization	27	3.9
Implementers at the community level:		
Community health workers (either paid or volunteer)	519	74.1
Research workers only for the project	238	34.0
Ministry of health worker or other government–paid health workers/professionals	304	43.4
Local community members (not trained as a CHW)	200	28.6
Expatriates	33	4.7

*Percentages add up to more than 100% because projects often utilized more than one Implementer.

in the 1940s and published in 1952 [33]. The next earliest report concerns the effectiveness of tetanus toxoid immunization in Columbia, South America, published in 1966 [34].

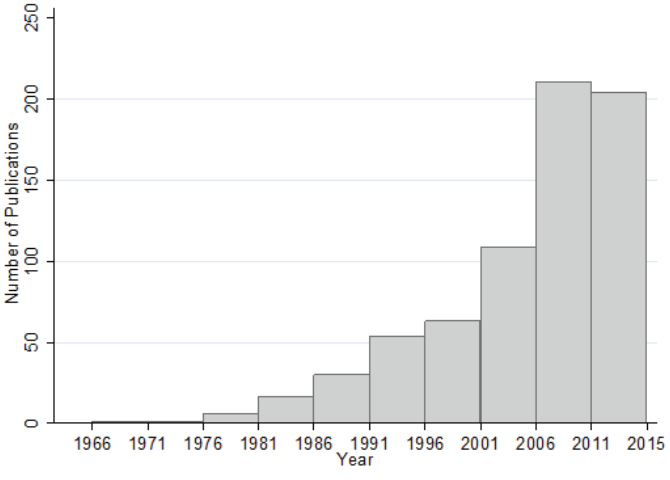

Figure 2. Number of assessments in data set by year of publication (in 5-year intervals).

Number of assessments completed over time

There has been a rapid growth in the number of assessments published between 1980 and 2015, but particularly in the period 2001–2011, the decade following the establishment of the Millennium Development Goals (MDGs) (**Figure 2**). The surge in publications is present both for maternal and for child/neonatal health studies (data not shown). In the five years from 2011 until the end of 2015 when the assessment retrieval ended, there was a slight decline in the number of publications.

Types of outcomes assessed

We identified a total of 239 outcomes measured in the 700 assessments included in the review: 56 maternal outcomes and 183 neonatal/child outcomes (see Tables S7 and S8 in **Online Supplementary Document**).

Common maternal health outcomes were changes in: mortality, receipt of antenatal care, attendance at delivery by a skilled provider, facility delivery, care for obstetric emergencies, receipt of nutritional supplements, receipt of tetanus toxoid vaccination, receipt of post–partum family planning, knowledge of safe birth practices, and screening for HIV and other sexually transmitted infections during pregnancy. Common neonatal and child health outcomes were: changes in mortality, serious morbidity, nutritional status, population coverage of healthy behaviors, and changes in the appropriate utilization of health services. In addition, some assessments contained outcome measures that did not qualify for the review but were included with other indicators that did qualify for the review. These include progress in psychomotor development, changes in health–related knowledge among parents and caretakers, quality of community case management of acute childhood illness provided by CHWs, and measures of improvements in health system capacity.

Types of research methodologies used to assess effectiveness

In the majority (61.0%) of the assessments, a control or comparison group was present. In almost three–fourths (72.5%), pre– and post–intervention data were collected. In 44.6% of the assessments, both data from a comparison group as well as pre– and post–intervention data were present. Randomized controlled assessment designs were present in 33.7% of the assessments. 27.4% of the assessments were uncontrolled before–after assessment designs. Reviewers considered the methodology to be adequate in 89.8% of the assessments, and they considered the assessment quality to be good, high, or exceptional for 88.4% of the assessments.

Source of financial support for assessments

The United States Agency for International Development (USAID) was far and away the largest source of financial support for the assessments included in our review, contributing to the financial support of one–third (33.4%) of the assessments included in the review. UNICEF supported the next largest number of assessments (15.8%), followed by the World Health Organization (14.2%), the Gates Foundation (10.7%), other UN agencies (7.7%), and the World Bank (6.2%) (**Table 4**). There were numerous other donors that funded a smaller number of assessments. In most (but not all) cases, the donor funded the project as well as the assessment.

Availability of the database for further analyses and potential further development of the database

We are not aware of any other similar database in existence. It serves as the basis for the subsequent articles in this series [32,35–40]. However, there is an opportunity for more analyses of the database than is reported in this series. Any of the project assessments included in this review are available to be shared with anyone who is interested (contact Henry Perry at *hperry2@jhu.edu*).

The potential exists for maintaining this as a dynamic database that is regularly updated and publicly available. And, the potential also exists for expanding this database beyond MNCH to include community–based approaches to other global health priorities such as HIV, tuberculosis, malaria, and chronic diseases.

Table 4. Leading sources of financial support for projects whose assessments were included in the database

Donor	Number of projects/assessments supported	% (n = 700)*
US Agency for International Development	233	33.3
UNICEF	110	15.7
World Health Organization (including the Pan American Health Organization)	99	14.1
The Bill and Melinda Gates Foundation	75	10.7
Other UN agency (eg, UNDP, UNFPA, UNHCR, WFP)	54	7.7
World Bank	43	6.1
Department for International Development (UK)	28	4.0
Canadian International Development Agency (CIDA)	23	3.3
Wellcome Trust	18	2.6

*Multiple funders may have supported a single project/assessment.

Limitations of the review

Our review is a comprehensive one, but we make no claim that it is a complete or systematic review. Resources and time constraints prevented screening other electronic databases beyond PubMed for reports that met the inclusion criteria. In addition, the USAID Child Survival and Health Grants program has an archive of more than 400 unpublished child survival project evaluations that meet the criteria for inclusion and are publicly available, but resource and time constraints were such that only one–fifth (80) of these could be included in our review. Since the data analysis and write up portion of this study began, we have identified several additional articles that would have qualified for the review. However, none of these would have changed the overall findings of our review.

This review is limited to documents that describe the impact of project interventions. As is well–known, program failures and serious challenges encountered in program implementation are rarely described in open–access documents or in the scientific literature. This means that a serious publication bias is present and should be recognized. Nonetheless, the inability to document these experiences does not detract from the value of the numerous assessments that have been included in our review that demonstrate effectiveness of CBPHC in improving MNCH.

The degree to which the assessments included in our review represent efficacy assessments as compared to effectiveness assessments is an important issue which we are not able to adequately explore. Efficacy assessments, of course, are carried out for projects that have been implemented under ideal circumstances, when field staff members have optimal training, supervision, resources, and logistical support, and when optimal community engagement has been established. These are conditions that often do not occur in routine settings. Effectiveness assessments, in contrast to efficacy assessments, are carried out under "real world" conditions. Our data extraction form did not collect information on this issue and, in fact, it is often difficult to determine exactly where a project might lie on a continuum between these end points. But it is the case that very few of the assessments in our database were of projects that were implemented without some type of international donor support or technical assistance. Thus, the database is not representative of the effectiveness of current day–to–day practice of CBPHC but rather of what has been achieved in special circumstances in which documentation of effectiveness was undertaken and in which presumably extra efforts had been made to assure the highest quality of implementation possible under the circumstances.

The degree to which these projects improved MNCH depended on many factors: the type(s) and number of interventions implemented, the quality of implementation, and myriad contextual factors. And, of course, the type of outcome indicator(s) employed is important as well. Given the heterogeneity of (1) the types of interventions implemented, (2) the manner in which they were implemented, and (3) the outcome measures used to assess outcomes, it is difficult to make definitive statements about the strength of the evidence, about the magnitude of effect for any specific intervention, or about the effectiveness of one specific approach to implementation compared to another. Rather, the aim of our study is to review the broad scope of evidence related to the effectiveness of CBPHC in improving MNCH and to draw conclusions about the overall effectiveness of CBPHC, the most common strategies used in implementation, and the potential for further strengthening of CBPHC to improve MNCH globally.

It is well–known that the use of family planning, birth spacing, and the reduction of unmet need for family planning all have favorable benefits for MNCH. Furthermore, the evidence on the effectiveness of CBPHC in increasing the coverage of family planning services is extensive. Thus, inclusion of this literature would have made our review more complete, but time and resources were not sufficient to carry this out.

Finally, our review has not included the effectiveness of CBPHC in reducing miscarriages and stillbirths. This topic is an important one but time and resources were not sufficient to carry this out either.

Subsequent articles in this series

Seven subsequent articles are being published in this series that answer the questions posed by the review. These include: (i) an analysis of the effectiveness of CBPHC in improving maternal health [35], (ii) an analysis of the effectiveness of CBPHC in improving neonatal health [36], (iii) an analysis of the effectiveness of CBPHC in improving child health [37], (iv) an analysis of the effectiveness of CBPHC in promoting equitable improvements in child health [40], (v) the strategies employed by effective CBPHC programs for achieving improvements in MNCH [38], (vi) an analysis of the common characteristics of integrated projects with long–term evidence of effectiveness in improving MNCH [39], and (vii) summary and recommendations of the Expert Panel [32].

CONCLUSIONS

An extensive database of the evidence regarding the effectiveness of CBPHC in improving MNCH has been assembled. Special attention has been given to how projects were implemented at the community level. The articles that follow in this series describe the findings of analyses of this database along with conclusions and recommendations of an Expert Panel. The aim of this series is to contribute to the formulation of policies and programs that will be useful for ending preventable maternal, neonatal and child deaths and for achieving universal access to care for women and their children by the year 2030 by strengthening CBPHC.

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REFERENCES

1 Jones G, Steketee RW, Black RE, Bhutta ZA, Morris SS. How many child deaths can we prevent this year? Lancet. 2003;362:65-71. Medline:12853204 doi:10.1016/S0140-6736(03)13811-1

2 Hill Z, Kirkwood B, Edmond K. Family and community practices that promote child survival, growth and development: a review of the evidence. Geneva: World Health Organization; 2004.

3 Lassi ZS, Kumar R, Bhutta ZA. Community-based care to improve maternal, newborn, and child health. 2016. In: Disease Control Priorities: Reproductive, Maternal, Newborn, and Child Health, Third Edition. Washington, DC: World Bank. Available: https://openknowledge.worldbank.org/bitstream/handle/10986/23833/9781464803482.pdf?sequence=3&isAllowed=y26 February 2017. Accessed: 27 February 2017.

4 Bhutta ZA, Black RE. Global maternal, newborn, and child health–so near and yet so far. N Engl J Med. 2013;369:2226-35. Medline:24304052 doi:10.1056/NEJMra1111853

REFERENCES

5 Black RE, Levin C, Walker N, Chou D, Liu L, Temmerman M, et al. Reproductive, maternal, newborn, and child health: key messages from Disease Control Priorities 3rd Edition. Lancet. 2016;388:2811-24.

6 Victora CG, Requejo JH, Barros AJ, Berman P, Bhutta Z, Boerma T, et al. Countdown to 2015: a decade of tracking progress for maternal, newborn, and child survival. Lancet. 2016;387:2049-59. Medline:26477328 doi:10.1016/S0140-6736(15)00519-X

7 Bhutta ZA, Darmstadt GL, Hasan BS, Haws RA. Community-based interventions for improving perinatal and neonatal health outcomes in developing countries: a review of the evidence. Pediatrics. 2005;115(2 Suppl):519-617. Medline:15866863 doi:10.1542/peds.2004-1441

8 Freeman P, Perry HB, Gupta SK, Rassekh B. Accelerating progress in achieving the millennium development goal for children through community-based approaches. Glob Public Health. Glob Public Health. 2012;7:400-19. Medline:19890758 doi:10.1080/17441690903330305

9 Bhutta ZA, Lassi ZS, Pariyo G, Huicho L. Global experience of Community Health Workers for delivery of health related Millennium Development Goals: a systematic review, country case studies, and recommendation for integration into national health systems. Geneva: World Health Organization and the Global Health Workforce Alliance; 2010. Available: http://www.who.int/workforcealliance/knowledge/publications/alliance/Global_CHW_web.pdf. Accessed: 26 February 2017.

10 Gogia S, Sachdev HS. Home visits by community health workers to prevent neonatal deaths in developing countries: a systematic review. Bull World Health Organ. 2010;88:658-66B. Medline:20865070 doi:10.2471/BLT.09.069369

11 Kidney E, Winter HR, Khan KS, Gulmezoglu AM, Meads CA, Deeks JJ, et al. Systematic review of effect of community-level interventions to reduce maternal mortality. BMC Pregnancy Childbirth. 2009;9:2. Medline:19154588 doi:10.1186/1471-2393-9-2

12 Lassi ZS, Haider BA, Bhutta ZA. Community-based intervention packages for reducing maternal and neonatal morbidity and mortality and improving neonatal outcomes. Cochrane Database Syst Rev. 2010;11:CD007754. Medline:21069697

13 Lewin S, Munabi-Babigumira S, Glenton C, Daniels K, Bosch-Capblanch X, van Wyk BE, et al. Lay health workers in primary and community health care for maternal and child health and the management of infectious diseases. Cochrane Database Syst Rev. 2010;3:CD004015. Medline:20238326

14 Salam RA, Haroon S, Ahmed HH, Das JK, Bhutta ZA. Impact of community-based interventions on HIV knowledge, attitudes, and transmission. Infect Dis Poverty. 2014;3:26. Medline:25126420 doi:10.1186/2049-9957-3-26

15 Sazawal S, Black RE. Effect of pneumonia case management on mortality in neonates, infants, and preschool children: a meta-analysis of community-based trials. Lancet Infect Dis. 2003;3:547-56. Medline:12954560 doi:10.1016/S1473-3099(03)00737-0

16 Schiffman J, Darmstadt GL, Agarwal S, Baqui AH. Community-based intervention packages for improving perinatal health in developing countries: a review of the evidence. Semin Perinatol. 2010;34:462-76. Medline:21094420 doi:10.1053/j.semperi.2010.09.008

17 Miller S, Abalos E, Chamillard M, Ciapponi A, Colaci D, Comande D, et al. Beyond too little, too late and too much, too soon: a pathway towards evidence-based, respectful maternity care worldwide. Lancet. 2016;388:2176-92. Medline:27642019 doi:10.1016/S0140-6736(16)31472-6

18 Chan M. Return to Alma-Ata. Lancet. 2008;372:865-6. Medline:18790292 doi:10.1016/S0140-6736(08)61372-0

19 Arole M, Kasaje D, Taylor C. The Christian Medical Commission's Role in the Worldwide Primary Health Care Movement. In: Taylor C, Desai A, Knutsson K, O'Dea-Knutsson P, Taylor-Ide D, editors. Partnerships for Social Development: A Casebook. Franklin, WV, USA: Future Generations; 1995.

20 Litsios S. The long and difficult road to Alma-Ata: a personal reflection. Int J Health Serv. 2002;32:709-32. Medline:12456122 doi:10.2190/RP8C-L5UB-4RAF-NRH2

21 Litsios S. The Christian Medical Commission and the development of the World Health Organization's primary health care approach. Am J Public Health. 2004;94:1884-93. Medline:15514223 doi:10.2105/AJPH.94.11.1884

22 Newell KW, editor. Health by the People. Geneva, Switzerland: World Health Organization; 1975.

23 WHO. UNICEF. Declaration of Alma-Ata. International Conference on Primary Health Care, Alma-Ata, USSR, 6-12 September 1978 Geneva, Switzerland: World Health Organization; 1978. Available: http://www.who.int/publications/almaata_declaration_en.pdf?ua=1. Accessed: 27 February 2017.

24 WHO. UNICEF (editors). International Conference on Primary Health Care, Alma Ata. 1978; USSR: World Health Organization, Geneva.

25 Ahmad OB, Lopez AD, Inoue M. The decline in child mortality: a reappraisal. Bull World Health Organ. 2000;78:1175-91. Medline:11100613

26 You D, Hug L, Ejdemyr S, Idele P, Hogan D, Mathers C, et al. Global, regional, and national levels and trends in under-5 mortality between 1990 and 2015, with scenario-based projections to 2030: a systematic analysis by the UN Inter-agency Group for Child Mortality Estimation. Lancet. 2015;386:2275-86. Medline:26361942 doi:10.1016/S0140-6736(15)00120-8

27 UNICEF. The State of the World's Children 2015: Reimagine the Future. Innovation for Every Child. New York: UNICEF; 2014. Available: http://sowc2015.unicef.org/. Accessed: 27 February 2017.

28 WHO, World Bank, UNICEF, UNFPA. Trends in Maternal Mortality: 1990 to 2015. 2015. World Health Organization. Available: http://apps.who.int/iris/bitstream/10665/194254/1/9789241565141_eng.pdf?ua=1. Accessed: 7 October 2016.

29 UNICEF. Tracking Progress in Maternal, Newborn and Child Survival. The 2008 Report New York: Geneva; 2008. Available: http://www.who.int/pmnch/Countdownto2015FINALREPORT-apr7.pdf. Accessed: 27 February 2017.

30 Evaluation: the top priority for global health. Lancet. 2010;375:526. Medline:20079530 doi:10.1016/S0140-6736(10)60056-6

31 Rohde JE, Wyon J, editors. Community-Based Health Care: Lessons from Bangladesh to Boston. Boston, MA: Management Sciences for Health (in collaboration with the Harvard School of Public Health); 2002.

32 Black R. Taylor. C, Expert Panel. Comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 8. conclusions and recommendations of an Expert Panel. J Glob Health. 2017;7:010908.

33 Kark SL, Cassel J. The Pholela Health Centre; a progress report. S Afr Med J. 1952;26:101-4. Medline:14913265

34 Newell KW, Duenas Lehmann A, LeBlanc DR, Garces Osorio N. The use of toxoid for the prevention of tetanus neonatorum. Final report of a double-blind controlled field trial. Bull World Health Organ. 1966;35:863-71. Medline:5338377

35 Jennings M, Pradhan S, Schleiff M, Sacks E, Freeman P, Gupta S, et al. Comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 2. maternal health findings. J Glob Health. 2017;7:010902.

36 Sacks E, Freeman P, Sakyi K, Jennings M, Rassekh B, Gupta S, et al. Comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 3. neonatal health findings. J Glob Health. 2017;7:010903.

37 Freeman P, Schleiff M, Sacks E, Rassekh B, Gupta S, Perry H. Comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 4. child health findings. J Glob Health. 2017;7:010904.

38 Perry H, Rassekh B, Gupta S, Freeman P. Comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 6. strategies used by effective projects. J Glob Health. 2017;7:010906.

39 Perry H, Rassekh B, Gupta S, Freeman P. Comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 7. Programs with evidence of long-term impact on mortality in children younger than five years of age. J Glob Health. 2017;7:010907.

40 Schleiff M, Kumapley R, Freeman P, Gupta S, Rassekh B, Perry H. Comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 5. equity effects. J Glob Health. 2017;7:010905.

Electronic supplementary material:
The online version of this article contains supplementary material.

journal of global health

PAPERS

A comprehensive review of the evidence regarding the effectiveness of community–based primary health care in improving maternal, neonatal and child health: 2. maternal health findings

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Background We summarize the findings of assessments of projects, programs, and research studies (collectively referred to as projects) included in a larger review of the effectiveness of community–based primary health care (CBPHC) in improving maternal, neonatal and child health (MNCH). Findings on neonatal and child health are reported elsewhere in this series.

Methods We searched PUBMED and other databases through December 2015, and included assessments that underwent data extraction. Data were analyzed to identify themes in interventions implemented, health outcomes, and strategies used in implementation.

Results 152 assessments met inclusion criteria. The majority of assessments were set in rural communities. 72% of assessments included 1–10 specific interventions aimed at improving maternal health. A total of 1298 discrete interventions were assessed. Outcome measures were grouped into five main categories: maternal mortality (19% of assessments); maternal morbidity (21%); antenatal care attendance (50%); attended delivery (66%) and facility delivery (69%), with many assessments reporting results on multiple indicators. 15 assessment reported maternal mortality as a primary outcome, and of the seven that performed statistical testing, six reported significant decreases. Seven assessments measured changes in maternal morbidity: postpartum hemorrhage, malaria or eclampsia. Of those, six reported significant decreases and one did not find a significant effect. Assessments of community–based interventions on antenatal care attendance, attended delivery and facility–based deliveries all showed a positive impact. The community–based strategies used to achieve these results often involved community collaboration, home visits, formation of participatory women's groups, and provision of services by outreach teams from peripheral health facilities.

Conclusions This comprehensive and systematic review provides evidence of the effectiveness of CBPHC in improving key indicators of maternal morbidity and mortality. Most projects combined community– and facility–based approaches, emphasizing potential added benefits from such holistic approaches. Community–based interventions will be an important component of a comprehensive approach to accelerate improvements in maternal health and to end preventable maternal deaths by 2030.

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Traditionally, maternal health programs in low–income settings have focused on improving the access to and quality of clinical services provided in health facilities. However, increasing facility delivery alone is likely insufficient for further substantial reductions in maternal mortality and morbidity [1,2]. The contribution that community–based primary health care (CBPHC) can make to improving maternal health has received much less attention. Although ready access to and appropriate utilization of primary health care centers and referral hospitals is essential to manage pregnancy complications [3,4], an increasing number of community–based interventions have been designed in an effort to accelerate improvements in maternal health.

Although improving maternal health by increasing the access to and the quality of maternal health care services has been acknowledged as a global health priority, recent progress in improving maternal health in low–income countries has been discouragingly slow, particularly in sub–Saharan Africa and parts of South Asia [5]. The Millennium Development Goal 5 (reducing maternal mortality by 75% between 1990 and 2015) was not met: only a 44% decline has been achieved globally – representing a decline from 385 to 216 maternal deaths per 100 000 live births between 1990 and 2015 [6].

The purpose of this paper is to review the available evidence regarding the effectiveness of CBPHC in improving maternal health broadly defined. It extends the focus of a previous review by Kidney et al. [7] that was limited to controlled studies of the effectiveness of community–level interventions in reducing maternal mortality. It also extends the findings of a recently published review by Lassi et al. (2016) [8] by providing a broader and more in–depth review of community–based approaches to improving maternal health.

This review is derived from assessments of projects, programs and research studies (hereafter referred to as projects) that implemented community–based interventions and measured their impact on maternal health. Our paper is part of a series on the effectiveness of CBPHC in improving maternal, neonatal and child health also reported in this journal [9–14].

METHODS

We conducted a search on PUBMED for assessments of CBPHC on maternal health. We defined such assessments of effectiveness broadly, as any document that assessed the effect of a CBPHC intervention on maternal health irrespective of inclusion of assessment of outcome on fetal, newborn or child health outcomes. The shared review methods for this series are described elsewhere in this series [9]. In addition, our maternal review searched additional databases including POPLINE, the Cochrane Review system, and CABI Publishing Database Subsets to identify additional documents. We included assessments identified from review articles. We made requests to knowledgeable professionals and organizations in the field of global public health for further listings of documents to be considered for inclusion. In order to provide a comprehensive set of documents that not only included clinical trials but also quasi–experimental designs, pre–post comparisons, program evaluations, and general descriptions of intervention effect, we used broad inclusion criteria.

Documents were eligible for inclusion in the present assessment if they: (1) involved an intervention intended to improve maternal health; (2) included interventions that took place outside of a health facility; (3) measured a change in maternal health (mortality, morbidity, nutritional status, or population coverage of a key maternal service) (eg, antenatal care attendance, facility–based delivery, attended delivery); (4) assessed an activity targeting a change in maternal health. We defined CBPHC, as a health intervention with a community component based outside of a physical health facility.

Two of the authors (HP, MJ) reviewed the abstracts of 7890 articles published on PUBMED through December 2015. Of these, 120 met criteria for inclusion. Additionally, 33 documents that were identified from the gray literature through searches of personal and colleague databases met criteria for inclusion. A total of 152 assessments met the final inclusion criteria. Two reviewers independently abstracted information from these assessments using a standardized data extraction form; a third independent reviewer resolved any discrepancies between the initial two reviews to provide a final summative review. The data were transferred to an electronic database and initially analyzed in EPI INFO version 3.5.4 (Epi Info, US Centers for Disease Control and Prevention, Atlanta, Georgia, USA). Microsoft Excel (Microsoft, Seattle WA, USA) was used for additional descriptive analyses. Appendix S1 in **Online Supplementary Document** contains the references for these 152 assessments; the assessments and year cited in the main text in parentheses are followed by the letter "S" and a number indicating the order of the reference in Ap-

pendix S1 in **Online Supplementary Document**. In the tables, these assessments are cited by the first author and year followed in parentheses by the letter "S" and a number indicating the order of the reference in Appendix S1 in **Online Supplementary Document**.

Reviewers who extracted data defined outcome indicators as primary and secondary depending on the type of project and its goals. In general, primary outcomes had study designs that provided sufficient power to detect a statistically significant difference in that outcome, while assessments of secondary outcomes were not similarly powered. Here we describe the basic characteristics of the full database of maternal articles and present a more detailed descriptive analysis of documents from this database that measured the effects of interventions on the primary outcomes of maternal mortality and morbidity. We describe the key characteristics of the interventions employed by each project as well as the strength of evidence of effectiveness. We include descriptions of documents that failed to report significance or reported statistically insignificant effects to provide a fair representation of the field and to avoid only reporting positive results.

To more fully explore the impact of community–based interventions on maternal health outcomes, we make a brief description of changes in the population coverage of antenatal care, attended delivery, and facility–based delivery. However, including these in as detailed an assessment as we have conducted for primary mortality and morbidity outcomes will be reserved for a subsequent article.

RESULTS

Community settings

Bangladesh, India, Pakistan and Nepal were the location of the largest number of assessments (16, 15, 14 and 11, respectively). Data from a total of 169 countries were included in these 152 assessments. Six assessments included data from multiple countries in multiple regions. Countries were from six geographic regions, with the majority of them in South–East Asia (41%) and West Sub–Saharan Africa (22%). The majority of the 152 assessments were performed in rural communities (83%), with 11% in peri–urban and 10% in urban locations. The largest percentage (48%) of the 152 assessments were performed for an intervention that took place at the district or sub–province level; 8% took place at the province level; and 3% at the national level. 30% of interventions took place in a group of communities, and 9% took place in a single community.

Interventions

Each assessment described the effectiveness of one or more discrete interventions, ranging in number from 1 to 27. (A copy of the data extraction form is contained in Online Supplementary Document of another paper in this series [9]). As shown in **Figure 1**, a small number of assessments (2%) described the implementation of only one intervention; a majority (72%) of the documents described packages comprised of between 1 and 10 interventions.

In total, the 152 assessments described 1298 discrete interventions. 57% of these interventions promoted or provided routine maternal health care. These activities included antenatal and postpartum visits, immunizations, attendance of a skilled attendant at delivery, or making referrals to higher levels of care.

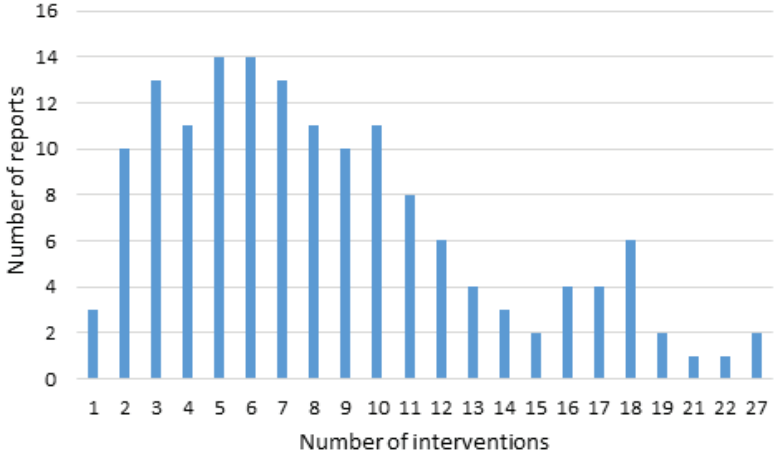

Figure 1. Number of interventions implemented in individual assessments of the effectiveness of community-based primary health care in improving maternal health.

37% of these interventions addressed medical complications of pregnancy. These activities included screening and treating medical conditions such as high–risk pregnancy, gestational diabetes, hypertensive disorders, and infections. 6% of these interventions targeted socio–economic conditions of the mother, including participation in micro–credit and savings groups, conditional cash transfers, women's empowerment programs, and participatory women's groups.

Box 1 describes three examples of intervention packages from three assessments with a larger number of kinds of interventions.

Categorization of outcome indicators

The 152 assessments described a multitude of outcome indicators. Categorization of outcome indicators aids in the assessment of intervention effectiveness. We extracted counts of indicators in five categories: (1) maternal mortality, (2) maternal morbidity, (3) population coverage of antenatal care attendance, (4) population coverage of deliveries by a skilled provider or a trained traditional birth attendant, and (5) population coverage of deliveries taking place at a facility. 19% of the assessments included maternal mortality as an indicator, and 21% measured maternal morbidity. In addition, 50% of the assessments measured antenatal care attendance; 66% measured attendance of deliveries by a skilled provider or trained traditional birth attendant; and 69% measured facility deliveries. A complete list of the outcome indicators among these 152 assessments is included in Online Supplementary Document of another article in this series [9].

Impact on maternal mortality

A maternal death was defined in the majority of assessments according to WHO definition: the death of a pregnant woman or a woman within 6 weeks of cessation of pregnancy, from any cause related to the

Box 1. Examples of community–based intervention packages for improving maternal health

Example 1. A community–based package implemented in 12 villages in rural India included the following interventions [15]:

- Provision of services at outreach sites by facility–based providers
- Provision of weekly antenatal clinics at outreach sites
- Provision of home visits for antenatal care by public health nurses
- Provision of treatment for simple illnesses by community health workers
- Provision of maternal education on child birth, child care, breastfeeding, immunizations, family spacing, and home economics by community health workers
- Distribution of iron/folate tablets in the community
- Identification of high–risk mothers in the community by community health workers and referral to a higher level of care

Example 2. A community–based package implemented in eight states in northern India included the following interventions [16]:

- Provision of antenatal and postnatal home visits by health workers
- Provision of tetanus immunizations
- Provision/promotion of iron–folic acid tablets
- Behavior change messages to promote saving money for birth planning and childbirth;
- Promotion of delivery at a facility and, if a home delivery is planned, promotion of the use of a skilled birth attendant
- Promotion of immediate postpartum breastfeeding

Example 3. A package of community–based interventions implemented in four districts of rural Bangladesh [17]:

- Formation of village health committees
- Training and linking traditional birth attendants to community health workers
- Promotion of family planning
- Identification of pregnancies at an early stage
- Promotion of birth planning
- Promotion of delivery by a trained health worker
- Promotion of immediate and exclusive breastfeeding
- Provision of antenatal care, delivery care, and postnatal care
- Promotion of vaccinations for pregnant women
- Referral for maternal complications
- Facilitate access to clinical services in health facilities

Table 1. Effect size, direction and significance of community–based primary health care on maternal mortality outcomes*

Document	Intervention type	Effect	Study population	Effect size and confidence interval	Significance level†
Colbourn 2013 [S39]	Participatory women's groups in the community and quality improvement at health centers	Increase	Two–by–two factorial cluster randomized controlled trial of community compared to facility intervention, 14 576 births during baseline and 20 576 births during intervention, in 3 districts in rural Malawi, over 29 months from 2007–2010	8% increase in odds of maternal mortality in facility + community arm compared to control (OR: 1.08, 95% CI, 0.46–2.57)	$P=0.854$
Manandhar 2004 [S83]	Participatory women's groups in the community, with 9 meetings per month and action–learning cycle	Decrease	Cluster–randomized controlled trial of 12 pairs of community clusters in 28 931 women in rural Nepal, over 2 years from 2001–2003	78% decrease in odds of maternal mortality in community intervention clusters compared to control clusters (OR: 0.22, 95% CI, 0.05–0.90), a maternal mortality ratio of 69 compared to 341 per 100 000 live births, respectively	**Significant, based on confidence interval** (*P* value not reported)
Zhenxuan 1995 [S152]	Linked community–based mass health education campaign with facility– and community–based strengthening of emergency services	Decrease	Quasi–experimental pilot study compared to control area, covering 8000 deliveries per year in one county in peri–urban China, over 3 years from 1985–1988	Maternal mortality ratio (per 100 000 live births) decreased by 75.7% in the intervention areas and by 5.5% ($P>0.05$) in the control areas	***P*<0.001**
Seim 2014 [S128]	Community mobilization to identify and refer protracted labor cases	Decrease	Pilot impact assessment, 12 254 births in rural Niger over 3 years from 2008–2011	Birth–related maternal mortality ratio fell by 73% over 3 y, from 630 to 170 per 100 000 live births	***P*<0.001**
Koenig 1988 [S70]	Provision of community–based family planning services	Decrease	Quasi–experimental study compared intervention to control areas using demographic surveillance data from 187 523 people in 149 villages, 70 in intervention and 79 in control, in Matlab, Bangladesh over 9 years from 1976–1985	Significant overall decrease in maternal mortality rate for intervention vs control (66 vs 121 deaths per 100 000 women of childbearing age) but no significant change in maternal mortality ratio (effect size not reported)	***P*<0.001**
Fauveau 1991 [S51]	Provision of antenatal and maternity care and surveillance of vital events in the home and community	Decrease	Non–randomized evaluation of intervention villages compared to neighboring non–intervention villages with 196.000 total population, in rural Bangladesh over 3 years from 1978–1981	65% decrease in odds of maternal mortality in intervention compared to control area (OR: 0.35, 95% CI, 0.13–0.93), or 140 vs 380 per 100 000 live births	***P*<0.05**
Fauveau 1990 [S50]	Provision of primary and preventive care (maternal and child) in the home and community	Decrease	Non–randomized evaluation of intervention villages compared to neighboring non–intervention villages with 196 000 total population, in rural Bangladesh over 3 years from 1978–1981	42% lower rate of maternal mortality in control vs intervention (authors reported RR in control over intervention: RR 1.73, 95% CI, 1.02–2.93) (rate of 5.0 vs rate of 8.6 per 10 000 women of child–bearing age)	***P*<0.05**
Asha–India 2008 [S19]	Provision of community–based primary and antenatal care and women's empowerment in slum communities	Decrease	Program evaluation of intervention population of 300 000 people in urban slums in India, over 20 years, reporting data from 2007–2008	Zero deaths in Asha slums compared to 540 per 100 000 live births in India country–wide	N/A (maternal mortality ratio in slum areas compared to overall country ratio)
CARE Nicaragua 2008 [S33]	Increase access and improve quality of maternal services through linking communities to facilities and through community mobilization and communication campaign	Decrease	Program evaluation of intervention in population of 174 367 (58 052 women of reproductive age) in 173 rural communities in Nicaragua over 5 years from 2002–2007	Maternal mortality rate decreased from 150 to 34 per 100 000 live births, with an annual average of 5500 deliveries over the 6 years of the intervention; maternal mortality ratio for the entire intervention area decreased from 119 to 60 per 100 000 live births over that time as well (a decrease of 49.2% compared to a national decrease of 42.6%)	N/A (maternal mortality rate decreased from baseline to endline in the primary referral hospital intervention area)
Curamericas–Guatemala–A&B 2007 [S41–42]	Care Groups and community–based impact–oriented care delivery/surveillance	Decrease	Program evaluation of intervention in population ranging in size from 11 123 (at end evaluation) to 14 272 (at mid–point) women of reproductive age, in 3 rural municipalities in Guatemala over 5 years from 2002–2007	Maternal mortality ratio decreased in all intervention areas relative to national data used as control (508 per 100 000 live births to zero, and 51124 per 100 000 live births to zero, over 4 years of data)	N/A (not powered sufficiently for statistical testing; diverse results)

Table 1. Continued

Document	Intervention type	Effect	Study population	Effect size and confidence interval	Significance level†
Foord 1995 [S54]	Provision of primary and antenatal care in the community, and establishment of referral linkages	Decrease	Non–randomized evaluation of intervention compared to similar control area, each with a population of 1300, in a rural district of the Gambia over 2 years from 1989–1991	1 death in intervention area compared to 5 deaths in control area, giving a maternal mortality ratio of 130 per 100 000 live births in the intervention compared to 700 in control area	N/A (not powered sufficiently for statistical testing)
Lamb 1984 [S73]	Provision of direct medical care, nutrition and vital statistics surveillance in community	Decrease	Non–randomized non–controlled evaluation of intervention impact in 4 villages with total population of 2000, in rural Gambia over 10 years from 1974–1984	No pregnancy–related deaths (per 1000 women of child bearing age) were observed in the community for the 8 years of intervention, compared to the annual 16 that would be expected using rates in comparable non–intervention areas	N/A (not powered sufficiently for statistical testing)
Emond 2002 [S47]	Provision of antenatal care in the community	Decrease	Non–randomized non–controlled evaluation of an intervention in a population of 42 000 in an urban district in Brazil over 30 months from 1995–1997	Maternal mortality ratio decreased from 335 per 100 000 live births prior to intervention, to zero maternal deaths during the 1 year after the intervention	N/A (not powered sufficiently for statistical testing)
Purdin 2009 [S117]	Community education campaign and creation of emergency obstetric centers linked to primary care centers	Decrease	Non–randomized non–controlled evaluation of intervention among community of 96 300 Afghan refugees in Pakistan over 4 years from 2004–2007	Annual maternal mortality ratio decreased from 291 to 102 per 100 000 live births over 4 years	N/A (baseline and endline rates calculated from two separate sources)
Findley 2015 [S53]	Behavior change and health systems integration	Decrease	Non–randomized evaluation of intervention compared to control and before compared to after, of 2360 women at baseline and 4628 at follow–up, in 3 states in northern Nigeria over 4 years from 2009–2013	Estimated maternal mortality ratio showed a larger decrease in the intervention than in the control communities, from 1270 to 1057 (interventions) and to 1262 (controls) per 100 000 live births	N/A (based on estimates)

N/A – not available; RR – rate ratio, CI – confidence interval, OR – odds ratio

* For assessments in which maternal mortality was the primary outcome indicator. The full references are shown in Appendix S1 in **Online Supplementary Document**.

† Significant results indicated in bold font.

pregnancy or its management, but excluding accidental causes. Of the 32 documents that assessed maternal mortality, 15 assessed mortality as a primary outcome indicator (**Table 1**). Of the 7 assessments that performed statistical significance testing, 6 reported significant decreases in mortality ranging from 42% to 78% and 1 suggested a trend toward increased mortality but this effect was not significant (**Table 1**). This suggestion of an increased mortality effect was only present when the facility–based intervention was analyzed together with the community arm, in comparison to the control arm. The suggestion of effect reversed in direction when the community arm was considered by itself against the control, with a 9% (non–significant) reduction in odds of maternal mortality rate (odds ratio OR 0.91, 95% confidence interval CI 0.51–1.63) (Colbourn 2013, reference [S39] in Appendix 1 in **Online Supplementary Document**). The design of the remaining 8 assessments with maternal mortality as a primary outcome did not permit statistical testing, but in all these assessments there was suggestion of decrease in maternal mortality. These reports suggested substantial impact, with four reporting a reduction to zero maternal deaths post–intervention (Asha–India 2008 [S19]; Curamericas Guatemala A&B 2007 [S41–42]; Lamb 1984 [S73]; Emond 2002 [S47]) and the remainder suggesting substantial decreases compared to regional or national population–level comparisons.

Impact on maternal morbidity

29 of the 152 assessments measured changes in maternal morbidity, most commonly measuring postpartum hemorrhage (14 assessments), anemia (13), eclampsia (8) or malaria (6). Of these 29 documents that assessed maternal morbidity, 7 assessed a discrete morbidity as a primary outcome indicator and so are described in **Table 2**. Six of these assessments reported a significant decrease in at least one of the maternal morbidity indicators; one assessment suggested a decrease but did not report significance testing, and none reported a worsening of maternal morbidity.

Table 2. Effect size, direction and significance of community–based primary health care on maternal morbidity outcomes*

Reference	Intervention type	Effect	Population	Effect size and confidence interval	Significance level†
Incidence of postpartum hemorrhage (PPH)					**PPH, Severe PPH‡**
Derman 2006 [S45]	Auxiliary nurse midwives (ANMs) administered oral misoprostol (or placebo) at home births they attended	Decrease	A randomized placebo–controlled trial assigned 812 women to oral misoprostol and 808 to placebo after home–based delivery by 25 ANMs, in rural India over 3 years from 2002–2005	47% decrease in incidence of PPH (6.4% in intervention vs 12.6% in control, RR: 0.53, 95% CI: 0.39–0.74); 83% decrease in severe PPH (0.2% in intervention vs 1.2% in control, RR: 0.16, 95% CI: 0.04–0.91). 1 case PPH prevented for every 18 women given chemoprophylaxis	**PPH $P<0.001$, severe PPH $P<0.001$**
Mobeen 2011 [S95]	Trained traditional birth attendants (TBAs) administered misoprostol (or placebo) at home deliveries they attended	Decrease	A randomized double–blind placebo-controlled trial assigned 534 women to oral misoprostol and 585 to placebo after home–based delivery by 81 TBAs, in one province in rural Pakistan over 24 months from 2006–2007	24% reduction in PPH after delivery (16.5% in intervention vs 21.9% in control, RR: 0.76, 95% CI 0.59–0.97); Insignificant decrease in severe PPH (RR: 0.57, 95% CI: 0.27–1.22)	**PPH $P<0.05$;** NS
Stanton 2013 [S138]	Community health officers injected prophylactic oxytocin (or placebo) at home births they attended	Decrease	A community–based, cluster–randomized controlled trial assigned births conducted by 54 community health officers were randomized to study arm by officer, in 4 rural districts in Ghana, 689 in intervention and 897 in control, over 19 months from 2011–2012	Reduction of 51% in PPH (2.6% in intervention vs 5.5% in control, RR: 0.49, 95% CI: 0.27–0.88) No significant change in severe PPH (1 case in intervention, 8 in control group)	**PPH $P<0.05$**; NS
Prevalence of malaria and anemia in malaria treatment interventions					
Mbonye 2008–5 [S90]	4 cadres of community health workers administered intermittent preventive treatment (IPT) for malaria in pregnancy in the community, compared to routine care in health clinics	Decrease	A non–randomized community trial assigned 2081 women (21 communities) to intervention and 704 women (4 communities) to control in 9 sub–counties of one district in central, rural Uganda over 21 months from 2003–2005	Prevalence of malaria episodes decreased from 49.5% to 17.6% in intervention and from 39.1% to 13.1% in control (both $P<0.001$). 67.5% of women in the community–based intervention received IPT compared to 39.9% in facility–based control ($P<0.001$)	**$P<0.001$;** Significance for RR difference in reported malaria was not reported
Mbonye 2008–3 [S89]	4 cadres of community health workers administered intermittent preventive treatment for malaria in pregnancy in the community, compared to in health clinics	Decrease	A non–randomized community trial assigned 2081 women (21 communities) to intervention and 704 women (4 communities) to control in 9 sub–counties of one district in central, rural Uganda over 21 months from 2003–2005	Decreased prevalence of reported malaria episodes in both community and facility distribution of IPT (64% in community, from 49.5% to 17.6%, vs 66% decrease in facilities, from 39.1%, to 13.1%) (both $P<0.001$)	**$P<0.001$** [Significance for RR difference in reported malaria was not reported)
Ndiaye 2009 [S105]	Positive deviance program using community–based volunteers to promote maternal health and nutrition, and to distribute iron supplements, to control anemia during pregnancy	Decrease (improvement)	A quasi–experimental design using pre–post evaluation of independent cross–section samples assessed 371 women in one community in rural Senegal over 9 months in 2003	75% reduction in risk of anemia, based on mean hemoglobin measurements, in the intervention compared to control area (no positive deviance) (OR: 0.25, 95% CI: 0.12–0.53)	**$P<0.003$§**
Eclampsia					
Shamsuddin 2005 [S130]	Quasi–experimental study involving community, home–based administration of magnesium sulfate to diagnosed eclamptic and severe eclamptic cases prior to referral to hospital, compared to control cases who did not receive injections	Decrease	256 cases from 3 districts in Bangladesh, 133 in intervention and 132 in control, over 6 months in 2001	Decreased number of mean convulsions in the intervention cases (4.7±SD2.64) compared to control cases (6.86±SD 2.97) ($P<0.001$)	**$P<0.001$**

CI – confidence interval, SD – standard deviation, OR – odds ratio, PPH – postpartum hemorrhage, NS – not (statistically) significant, RR – rate ratio

*For assessments that analyzed maternal morbidity as a primary outcome indicator. The full references are shown in Appendix S1 in **Online Supplementary Document**.

†Significant results indicated in bold font.

‡PPH defined in each assessment as blood loss ≥500 mL; severe PPH defined in each assessment as blood loss ≥1000 mL.

§Chi–square test of difference between control and intervention.

Postpartum hemorrhage

Three of the seven documents measured change in postpartum hemorrhage following a preventive intervention delivered by a community health worker. These documents used the standard definition of measured blood loss greater than or equal to 500mL, and defined severe postpartum hemorrhage as blood loss greater than or equal to 1000mL (Kapungu 2013 [S65]; Fauveau 1990 [S50]; Derman 2006 [S45]).

The three measurements of reduction in postpartum hemorrhage were statistically significant, with decreases ranging from 24% to 66% (**Table 2**). One assessment reported a significant decrease in severe postpartum hemorrhage, and the remaining two did not have a significant effect on severe postpartum hemorrhage.

Malaria

Two assessments reported measures of primary outcomes related to malaria, including the prevalence of anemia in malaria–endemic areas (two assessments) and the prevalence of maternal malarial episodes (one assessment). Of note, two of these assessments pertained to different aspects of a single intervention but were reported in separate peer–reviewed publications. One document reported equivalent, significant decreases in anemia in both community–based and facility–based intermittent preventive treatment (IPT) of malaria in pregnancy, (mean hemoglobin increased by 6.7% with 2 doses of IPT in both arms) (Mbonye 2008–5 [S90]). However, the women in the community arm received their first dose of IPT as recommended (during the second trimester) more frequently than the women in the facility arm (92.4% in the community vs 76.1% in the facility, $P<0.001$). Women in the community arm also received IPT at a significantly earlier stage of pregnancy compared to those in the facility arm (21 weeks vs 23 weeks, $P<0.001$), and the results described significantly higher adherence to the recommended two doses in the community arm compared to the facility arm. The community–based approach increased access to and use of IPT (Mbonye 2008–5, [S90]). The second assessment measured prevalence of reported malaria episodes and reported similar decreases in both community and facility distribution groups, but did not report significance testing of the relative difference in risk (Mbonye 2008–3 [S89]). One report assessed the prevalence of anemia, reporting a significant decrease of 75% in the intervention area vs the control area (Ndiaye 2009 [S105]).

Eclampsia

One assessment measured frequency of convulsions in eclamptic or pre–eclamptic cases who received magnesium sulfate injections at home prior to hospital transfer, reporting a significant decrease compared to cases who did not receive injections at home (Shamsuddin 2005, [S130]).

Impact on population coverage of evidence–based interventions

Antenatal care

Of the 37 assessments that measured coverage of antenatal attendance as a primary outcome indicator, 34 assessments reported increased attendance for antenatal care (ANC). No assessments observed a decrease in ANC coverage. Three assessments found no change in coverage, and we describe those three here in some detail.

The first assessment that found no change in ANC coverage (Helen Keller International 2003, [S60]) was an evaluation of a pilot program in Mozambique that provided iron and folic acid along with anemia–related health education to communities with a high anemia burden. Both recipient (intervention) and non–recipient (control) barrios showed some increases and some decreases on numerous outcome indicators such as knowledge of anemia, ingestion of iron/folic acid supplements, and reported anemia during most recent pregnancy.

The second assessment with no change in ANC attendance (More 2012 [S97]) was a cluster–randomized controlled trial testing the impact of creating and mobilizing women's groups in urban slums in Mumbai, India for the purpose of improving perinatal health, including increasing attendance at ANC clinics which had been strengthened through a city–wide maternal and newborn health care program for the urban poor. Although the assessment did report a reduction in the odds of a set of maternal morbidities in the intervention compared to control group (OR 0.60, 95% CI 0.38–0.94), there were no improvements in ANC attendance or other outcomes such as institutional delivery, breastfeeding, care–seeking, stillbirth rate, or neonatal mortality.

The third assessment that found no change in ANC coverage (Langston 2014, [S74]) was a mixed–methods evaluation of integrated community case management for childhood illness that was combined with promotion of maternal ANC attendance. ANC attendance increased in both control and intervention communities, but the difference was not statistically significant.

Changes in attended delivery

12 assessments measured coverage of the presence of a skilled or trained attendant at delivery as a primary outcome indicator. All 12 assessments reported an increase in the coverage of attended deliveries. The precise definition of a skilled or trained birth attendant varied among the assessments, and we have not attempted to standardize the definition here. Nine assessments specifically measured percentage of deliveries attended by a "skilled birth attendant," while one assessment measured the percentage of deliveries attended by a trained traditional birth attendant. Two assessments measured the attendance by a traditional birth attendant as compared to completely unattended deliveries. The two assessments that calculated the statistical significance of coverage changes found a significant increase.

Changes in facility–based deliveries

Eight assessments measured the percentage of births occurring in a facility as a primary outcome indicator. None of these assessments observed a decrease in coverage; one observed no change in coverage and seven reported an increase. The types of facilities included in these assessments were hospitals, health centers, and birthing huts.

Implementers

Community health workers (CHWs) were involved in intervention implementation in 132 of the 152 projects included in our database. In addition to CHWs, project implementers included local government health professionals (78/152 projects), local community members not trained as CHWs (48/152 projects), research staff hired specifically to implement the project (31/152 projects), and expatriates (4/152 projects). Multiple categories of implementers were present in three–fourths (71%) of the individual projects. CHWs were most frequently combined with local government health officials (69 assessments), and with non–CHW members of the local community (40 assessments).

Implementation strategies

Common strategies used to implement the interventions discussed above are highlighted here.

A typical set of implementation strategies is the following (Baqui 2008 [S24]):

- Used existing government ministry of health infrastructure (facilities and personnel)
- Combined maternal and newborn interventions
- Integrated nutrition with primary care services
- Delivered services and promoted interventions through both skilled and traditional health workers
- Used home visits and health centers to deliver interventions

Community–based strategies used to strengthen maternal health often overlap with community–based strategies to improve neonatal and child health. Strategies to implement community–based interventions for improving neonatal and child health are reported elsewhere [13]. These common strategies include:

- Established community collaborations such as the formation of community health committees
- Engaged community leaders to mobilize communities for a health–related activity
- Formed community groups or collaborated with existing groups (including women's groups and micro–credit savings groups)
- Engaged communities in the selection and support of CHWs
- Engaged communities in the planning and/or evaluation of CBPHC programming

Home visits were a common strategy used to identify pregnant women, to provide health services and education/counseling, as well as to promote healthy behaviors such as family planning and facility delivery. Home visits were also used to provide postpartum maternal care and identify postpartum mothers with problems requiring referral. The formation and strengthening of participatory women's groups was a common strategy to motivate women and their families to seek antenatal, delivery and emergency obstetrical care. Outreach visits to the community by a mobile health team based at a peripheral health facility were also a common approach to provide prenatal care, family planning services, and maternal immunizations.

Community–based approaches, particularly through home visits provided by CHWs, are commonly used to increase the coverage of insecticide–treated bed nets for pregnant women and to expand the coverage

of intermittent preventive treatment of malaria in malaria–endemic areas. These are interventions that are effective not only for improving maternal outcomes but also for improving perinatal and neonatal outcomes. Community–based approaches to expand the detection of women with HIV infection and to increase the coverage of anti–retroviral treatment of HIV–positive pregnant women include CHWs making home visits and mobile outreach teams.

Health systems strengthening strategies associated with CBPHC for improving maternal health include facilitating referrals (by forming community emergency response committees, community transport systems, and community savings or insurance schemes to cover transport and hospital costs when obstetric emergencies arise). Other health–system–related activities often carried out by projects that also implemented CBPHC interventions included strengthening the quality of care provided at peripheral health facilities (by improving logistics and training staff), and strengthening the supervisory system of community–level workers.

DISCUSSION

This analysis provides evidence for a positive impact of CBPHC interventions on reducing maternal morbidity, increasing population coverage of evidence–based interventions, and possibly contributing to reductions in maternal mortality in selected settings. Six of the seven assessments that were able to measure the statistical significance of the change in maternal mortality showed a statistically significant decrease. There were eight additional assessments that reported trends in maternal mortality but could not measure the statistical significance of the impact. All eight of these reported a favorable effect on maternal mortality. In contrast to a 2010 Cochrane review of the impact of community–based interventions, which reported reductions in maternal morbidity but no reduction in maternal mortality [18], our inclusion criteria were broad and allowed non–randomized assessments as well as assessments from the gray literature.

All three assessments of the statistical significance of impact of CBPHC interventions on the incidence of postpartum hemorrhage showed significant decreases. One of the three showed a significant decrease in the incidence of *severe* postpartum hemorrhage (which was a secondary outcome for all three projects). Three assessments of CBPHC interventions on maternal malaria and malaria–related anemia all showed significant positive effects, and one assessment of CBPHC interventions on eclampsia showed a significant positive effect.

Our analysis of the effectiveness of CBPHC approaches in increasing the population coverage of evidence–based interventions focused on three interventions: antenatal care attendance, delivery trained provider, and facility–based delivery. Global recommendations for attendance at antenatal care have evolved over time to support increased contacts [19], and the provision of antenatal care as a community–based intervention may help to expand the coverage of more frequent, high–quality and woman–centered pregnancy care in resource–constrained settings.

Delivery attended by a skilled provider improves delivery outcomes [20], but delivery by a fully and formally trained midwife or other highly skilled provider is often beyond the short–term capacity of many countries for all births. Strategies that integrate both skilled and traditional birth attendants into the health system are important to increase skilled birth attendance [21,22]. Delivery at a health facility improves access to emergency and critical care for prompt attention to life–threatening maternal complications [3], although the literature points out deficiencies in quality that are commonly observed at facilities [2] and some argue that facility delivery is not a necessary requisite for the reduction of maternal mortality [23,24]. Despite these observations, promoting facility deliveries has been a focus of many interventions aimed at reaching the 2015 Millennium Development Goals for maternal health [25] and now for reaching the 2030 Sustainable Development Goals. However, recent literature suggests that a high rate of institutional delivery by itself is insufficient to reduce maternal mortality ratios [1,26].

A large proportion of the low–income populations globally live more than one hour away from a health facility [4], making utilization of health facilities and emergency care services a challenge. Therefore it is important to strengthen community–based interventions to promote antenatal care attendance, attended delivery, and facility delivery.

The vast majority of community–based primary care interventions described by assessments included in this study were implemented by a wide variety of different types of community–based health workers. It is important to continue efforts to incorporate them in the maternal care process as well as traditional birth attendants, who can serve as doulas (birth companions for facility births) and collaborators in the

delivery [27]. Community–based interventions show great potential for reducing morbidity of mothers from malaria and hemorrhage following home delivery.

Study limitations

Maternal mortality is a rare event, even in settings where maternal mortality is relatively high: even with a maternal mortality ratio of 1000, only 1% of live births are associated with a maternal death. Thus, the demonstration of a statistically significant decline in maternal mortality is a challenge for field programs. As our findings indicate, there are numerous assessments in which there is a suggestion of maternal mortality impact, but the decline does not reach statistical significance. Additionally, there are examples in the literature in which the same community–based intervention shows a statistically significant reduction in maternal mortality in one setting [28] but not in another [29]. One of the explanations for this finding is that the study that did not show a statistically significant change was not adequately powered (meaning that an impact may have been achieved in reality but due to the small sample size it did not reach statistical significance).

This review did not focus on assessments of cost–effectiveness. It is worth noting that studies of the cost–effectiveness of community–based approaches to improving maternal health are rare. Additionally, it is important to note that there are certain settings in which CBPHC may not be effective in improving maternal health – for example in settings where high–quality facility–based care is available and utilized and therefore levels of maternal health are already high. Thus, the cost–effectiveness of CPBHC may be highly dependent on the context. Although evidence of the cost–effectiveness of community–based approaches for improving neonatal and child health care has been summarized [8], there is a need for more research on the cost–effectiveness of community–based maternal health interventions.

The local context in which the assessments were carried out is important to more fully understand which CBPHC components are most useful in which setting. The availability of trained personnel to provide maternity care, the availability and utilization of health facilities, and the local geographic context are all important in assessing how CBPHC can most effectively contribute to improve maternal health. However, to adequately explore these issues is beyond the scope of this paper.

This review did not assess the effects of community–based family planning interventions on maternal health because their effects are indirect and not readily measured in specific program settings, including in the assessments included in our review. However, there is extensive evidence that family planning is important for improving maternal health (by, among other things, reducing the number of maternal deaths simply by reducing the number of women who become pregnant). There is extensive evidence that family planning can be effectively provided through a community–based primary health care platform [30–32]. Had assessments of the effectiveness of community–based family planning been included in our review, we expect that the evidence for the effectiveness of CBPHC in improving maternal health would have been even more compelling.

Our inclusion of a wide variety of intervention packages precludes us from being able to make specific recommendations for or against intervention components in community–based approaches. However, other authors have summarized potential frameworks to select appropriate intervention package components [33,34]. The nature of intervention packages evolves with technology and with the emergence of new interventions. For example, mhealth strategies involving community health workers and women of reproductive age have the potential to link clients with services and promote utilization of services [35]. However, no studies assessing mHealth interventions were identified for our review. In addition, the lack of standardization of indicator measurement limits our ability to draw detailed conclusions. Finally, the richness of this data set is such that only a limited analysis of the data is provided here. Further analyses are needed, as pointed out at several points in this paper.

CONCLUSIONS

The evidence provided here supports the recommendation that CBPHC is an important component of a comprehensively–designed maternal health program – not only because of the direct effects it can have on reducing maternal morbidity and its potential to contribute to reductions in maternal mortality, but also because of its contributions to the promotion of appropriate facility utilization for ANC, childbirth, and referral of obstetrical emergencies. Finally, the closely related contributions that CBPHC can make to improving neonatal health are important as well but summarized in another article in this series [10].

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REFERENCES

1 Randive B, Diwan V, De Costa A. India's Conditional Cash Transfer Programme (the JSY) to promote institutional Birth: is there an association between institutional birth proportion and maternal mortality? PLoS One. 2013;8:e67452. Medline:23826302 doi:10.1371/journal.pone.0067452

2 Hulton LA, Matthews Z, Stones RW. Applying a framework for assessing the quality of maternal health services in urban India. Soc Sci Med. 2007;64:2083-95. Medline:17374551 doi:10.1016/j.socscimed.2007.01.019

3 Kayongo M, Rubardt M, Butera J, Abdullah M, Mboninyibuka D, Madili M. Making EmOC a reality–CARE's experiences in areas of high maternal mortality in Africa. Int J Gynaecol Obstet. 2006;92:308-19. Medline:16442536 doi:10.1016/j.ijgo.2005.12.003

4 Pearson L, Shoo R. Availability and use of emergency obstetric services: Kenya, Rwanda, Southern Sudan, and Uganda. Int J Gynaecol Obstet. 2005;88:208-15. Medline:15694109 doi:10.1016/j.ijgo.2004.09.027

5 WHO, World Bank, UNICEF, UNFPA. Trends in Maternal Mortality: 1990 to 2015. 2015. Available: http://www.who.int/reproductivehealth/publications/monitoring/maternal-mortality-2015/en/. Accessed: 26 April 2017.

6 Alkema L, Chou D, Hogan D, Zhang S, Moller AB, Gemmill A, et al. Global, regional, and national levels and trends in maternal mortality between 1990 and 2015, with scenario-based projections to 2030: a systematic analysis by the UN Maternal Mortality Estimation Inter-Agency Group. Lancet. 2016;387:462-74. Medline:26584737 doi:10.1016/S0140-6736(15)00838-7

7 Kidney E, Winter HR, Khan KS, Gulmezoglu AM, Meads CA, Deeks JJ, et al. Systematic review of effect of community-level interventions to reduce maternal mortality. BMC Pregnancy Childbirth. 2009;9:2. Medline:19154588 doi:10.1186/1471-2393-9-2

8 Lassi ZS, Kumar R, Bhutta ZA. Community-based care to improve maternal, newborn, and child health. 2016. In: Disease Control Priorities: Reproductive, Maternal, Newborn, and Child Health, Third Edition [Internet]. Washington, DC: World Bank; [263-94]. Available: https://openknowledge.worldbank.org/bitstream/handle/10986/23833/9781464803482.pdf?sequence=3. Accessed: 26 April 2017.

9 Perry H, Rassekh B, Gupta S, Wilhelm J, Freeman P. A comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 1. rationale, methods and database description. J Glob Health. 2017;7:010901.

10 Sacks E, Freeman P, Sakyi K, Jennings M, Rassekh B, Gupta S, et al. A comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 3. neonatal health findings. J Glob Health. 2017;7:010903.

11 Freeman P, Schleiff M, Sacks E, Rassekh B, Gupta S, Perry H. A comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 4. child health findings. J Glob Health. 2017;7:010904.

12 Schleiff M, Kumapley R, Freeman P, Gupta S, Rassekh B, Perry H. A comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 5. equity effects. J Glob Health. 2017;7:010905.

13 Perry H, Rassekh B, Gupta S, Freeman P. A comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 6. strategies used by effective projects. J Glob Health. 2017;7:010906.

14 Perry H, Rassekh B, Gupta S, Freeman P. A comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 7. programs with evidence of long-term impact on mortality in children younger than five years of age. J Glob Health. 2017;7:010309.

15 Dutt D, Srinivasa DK. Impact of maternal and child health strategy on child survival in a rural community of Pondicherry. Indian Pediatr. 1997;34:785-92. Medline:9492416

16 Baqui A, Williams EK, Rosecrans AM, Agrawal PK, Ahmed S, Darmstadt GL, et al. Impact of an integrated nutrition and health programme on neonatal mortality in rural northern India. Bull World Health Organ. 2008;86:796-804. Medline:18949217 doi:10.2471/BLT.07.042226

17 Rahman M, Jhohura FT, Mistry SK, Chowdhury TR, Ishaque T, Shah R, et al. Assessing Community Based Improved Maternal Neonatal Child Survival (IMNCS) Program in Rural Bangladesh. PLoS One. 2015;10:e0136898. Medline:26340672 doi:10.1371/journal.pone.0136898

18 Lassi ZS, Haider BA, Bhutta ZA. Community-based intervention packages for reducing maternal and neonatal morbidity and mortality and improving neonatal outcomes. Cochrane Database Syst Rev. 2010;11:CD007754. Medline:21069697

19 WHO. Antenatal care in developing countries. Promises, achievements and missed opportunities: an analysis of trends, levels and differentials. 2003. Available: http://www.who.int/reproductivehealth/publications/maternal_perinatal_health/9241590947/en/. Accessed: 26 April 2017.

20 Homer CS, Friberg IK, Dias MA, ten Hoope-Bender P, Sandall J, Speciale AM, et al. The projected effect of scaling up midwifery. Lancet. 2014;384:1146-57. Medline:24965814 doi:10.1016/S0140-6736(14)60790-X

21 Byrne A, Morgan A. How the integration of traditional birth attendants with formal health systems can increase skilled birth attendance. Int J Gynaecol Obstet. 2011;115:127-34. Medline:21924419 doi:10.1016/j.ijgo.2011.06.019

22 Lane K, Garrod J. The return of the Traditional Birth Attendant. J Glob Health. 2016;6:020302. Medline:27606054 doi:10.7189/jogh.06.020302

23 Costello A, Azad K, Barnett S. An alternative strategy to reduce maternal mortality. Lancet. 2006;368:1477-9. Medline:17071268 doi:10.1016/S0140-6736(06)69388-4

24 Miller S, Cordero M, Coleman AL, Figueroa J, Brito-Anderson S, Dabagh R, et al. Quality of care in institutionalized deliveries: the paradox of the Dominican Republic. Int J Gynaecol Obstet. 2003;82:89-103, discussion 87-8. Medline:12834953 doi:10.1016/S0020-7292(03)00148-6

25 WHO. The World Health Report 2005 - make every mother and child count. 2005. Available: http://www.who.int/whr/2005/whr2005_en.pdf?ua=1. Accessed: 26 April 2017.

26 Souza JP, Gulmezoglu AM, Vogel J, Carroli G, Lumbiganon P, Qureshi Z, et al. Moving beyond essential interventions for reduction of maternal mortality (the WHO Multicountry Survey on Maternal and Newborn Health): a cross-sectional study. Lancet. 2013;381:1747-55. Medline:23683641 doi:10.1016/S0140-6736(13)60686-8

27 Stollak I, Valdez M, Rivas K, Perry H. Casas Maternas in the Rural Highlands of Guatemala: A Mixed-Methods Case Study of the Introduction and Utilization of Birthing Facilities by an Indigenous Population. Glob Health Sci Pract. 2016;4:114-31. Medline:27016548 doi:10.9745/GHSP-D-15-00266

28 Manandhar DS, Osrin D, Shrestha BP, Mesko N, Morrison J, Tumbahangphe KM, et al. Effect of a participatory intervention with women's groups on birth outcomes in Nepal: cluster-randomised controlled trial. Lancet. 2004;364:970-9. Medline:15364188 doi:10.1016/S0140-6736(04)17021-9

29 Azad K, Barnett S, Banerjee B, Shaha S, Khan K, Rego AR, et al. Effect of scaling up women's groups on birth outcomes in three rural districts in Bangladesh: a cluster-randomised controlled trial. Lancet. 2010;375:1193-202. Medline:20207412 doi:10.1016/S0140-6736(10)60142-0

30 Singh S, Darroch J, Ashford L. Adding It Up: The Costs and Benefits of Investing in Sexual and Reproductive Health 2014. 2014. Available: https://www.guttmacher.org/sites/default/files/report_pdf/addingitup2014.pdf. Accessed. 26 April 2017.

31 Prata N, Vahidnia F, Potts M, Dries-Daffner I. Revisiting community-based distribution programs: are they still needed? Contraception. 2005;72:402-7. Medline:16307960 doi:10.1016/j.contraception.2005.06.059

32 Stanback J, Spieler J, Shah I, Finger WR. Community-based health workers can safely and effectively administer injectable contraceptives: conclusions from a technical consultation. Contraception. 2010;81:181-4. Medline:20159172 doi:10.1016/j.contraception.2009.10.006

33 Kearns AD, Caglia JM, Ten Hoope-Bender P, Langer A. Antenatal and postnatal care: a review of innovative models for improving availability, accessibility, acceptability and quality of services in low-resource settings. BJOG. 2016;123:540-8. Medline:26694075 doi:10.1111/1471-0528.13818

34 Lunze K, Higgins-Steele A, Simen-Kapeu A, Vesel L, Kim J, Dickson K. Innovative approaches for improving maternal and newborn health–a landscape analysis. BMC Pregnancy Childbirth. 2015;15:337. Medline:26679709 doi:10.1186/s12884-015-0784-9

35 Labrique AB, Vasudevan L, Kochi E, Fabricant R, Mehl G. mHealth innovations as health system strengthening tools: 12 common applications and a visual framework. Glob Health Sci Pract. 2013;1:160-71. Medline:25276529 doi:10.9745/GHSP-D-13-00031

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PAPERS

Comprehensive review of the evidence regarding the effectiveness of community–based primary health care in improving maternal, neonatal and child health: 3. neonatal health findings

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Background As the number of deaths among children younger than 5 years of age continues to decline globally through programs to address the health of older infants, neonatal mortality is becoming an increasingly large proportion of under–5 deaths. Lack of access to safe delivery care, emergency obstetric care and postnatal care continue to be challenges for reducing neonatal mortality. This article reviews the available evidence regarding the effectiveness of community–based primary health care (CBPHC) and common components of programs aiming to improve health during the first 28 days of life.

Methods A database comprising evidence of the effectiveness of projects, programs and field research studies (referred to collectively as projects) in improving maternal, neonatal and child health through CBPHC has been assembled and described elsewhere in this series. From this larger database (N = 548), a subset was created from assessments specifically relating to newborn health (N = 93). Assessments were excluded if the primary project beneficiaries were more than 28 days of age, or if the assessment did not identify one of the following outcomes related to neonatal health: changes in knowledge about newborn illness, care seeking for newborn illness, utilization of postnatal care, nutritional status of neonates, neonatal morbidity, or neonatal mortality. Descriptive analyses were conducted based on study type and outcome variables. An equity assessment was also conducted on the articles included in the neonatal subset.

Results There is strong evidence that CBPHC can be effective in improving neonatal health, and we present information about the common characteristics shared by effective programs. For projects that reported on health outcomes, twice as many reported an improvement in neonatal health as did those that reported no effect; only one study demonstrated a negative effect. Of those with the strongest experimental study design, almost three–quarters reported beneficial neonatal health outcomes. Many of the neonatal projects assessed in our database utilized community health workers (CHWs), home visits, and participatory women's groups. Several of the interventions used in these projects focused on health education (recognition of danger signs), and promotion of and support for exclusive breastfeeding (sometimes, but not always, including early breastfeeding). Almost all of the assessments that included a measurable equity component showed that CBPHC produced neonatal health benefits that favored the poorest segment of the project population. However, the studies were quite biased in geographic scope, with more than half conducted in South Asia, and many were pilot studies, rather than projects at scale.

Conclusions CBPHC can be effectively employed to improve neonatal health in high–mortality, resource–constrained settings. CBPHC is especially important for education and support for pregnant and postpartum mothers and for establishing community–facility linkages to facilitate referrals for obstetrical emergencies; however, the latter will only produce better health outcomes if facilities offer timely, high–quality care. Further research on this topic is needed in Africa and Latin America, as well as in urban and peri–urban areas. Additionally, more assessments are needed of integrated packages of neonatal interventions and of programs at scale.

Despite marked reductions in overall child mortality globally since 1990, 2.7 million live–born infants still die annually during their first month of life [1]. Neonatal mortality is becoming an increasingly large proportion of mortality among children younger than 5 years of age, at present accounting for 45% of under–5 deaths [2]. Approximately 73% of neonatal deaths occur during the first week of life [3], 36% on the first day of life [3] and 32% during the first 6 hours of life [4]. The key causes of death among neonates are complications of preterm birth, intrapartum–related complications (often birth asphyxia), and infections [5]. Given that 51% of births in the least developed countries, 49% of births in sub–Saharan Africa, and 41% of births in South Asia still take place outside of health facilities [1], and the continuing challenges with providing high–quality care in facilities, community–based approaches to improve neonatal health will be essential for the near term to promote healthy home practices and to reach newborns during their birth and soon thereafter when they have a high risk of mortality. Community–based efforts in education, support and referral may be important in settings with high facility delivery rates as well.

Community–based approaches to reducing neonatal mortality are of particular importance in low–income settings where home deliveries are common and access to facility–based care for neonates is limited [2,6,7]. This paper analyzes the findings related to the effectiveness of community–based primary health care (CBPHC) in improving neonatal health using a subset of articles from a database assembled for a broader review of the effectiveness of community–based primary health (CBPHC) in improving child health. It complements other reviews that have been carried out on this topic [7–9]. Projects were assessed by their study design, outcome variables, program components, and reported neonatal health impact.

METHODS

The methodology for assembling a database of 548 assessments of the effectiveness of CBPHC in improving child health, including the search strategy, has been described elsewhere in this series [10]. In brief, we considered CBPHC to be any activity in which one or more health–related interventions were carried out in the community outside of a health facility. There could also be associated activities that took place in health facilities. The larger study conducted a search of published documents in PubMed, personal sources, and the grey literature for documents that described the implementation of CBPHC and assessed the effect of these projects, programs, or field research studies (described collectively as projects) on mortality, morbidity, nutritional status, or population coverage of an evidence–based intervention. Of 4276 articles identified for screening via PubMed, 433 qualified for the review. In addition, 115 reports were identified from the grey literature and elsewhere, yielding a total of 548 neonatal and child health assessments included in the review. Two reviewers independently extracted information about the assessment and a third independent reviewer resolved any differences. The data were transferred to an electronic database using EPI INFO version 3.5.4 (US Centers for Disease Control and Prevention, Atlanta, Georgia, USA).

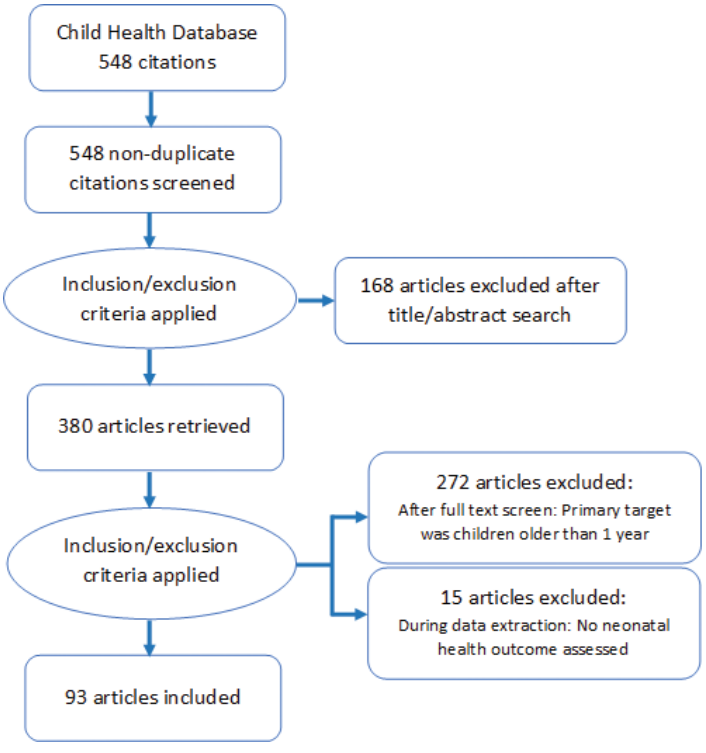

Figure 1. Selection of assessments for inclusion in the neonatal health review.

Starting with the child health data set, assessments were selected for the analysis of neonatal health in a three–stage process (**Figure 1**). In the first stage, articles were selected that had been coded with relevant interventions pertaining to neonates. These interventions, as defined on the data extraction form, were: neonatal/perinatal health; breastfeeding; child weight/height (including birth weight); immunizations; diarrhea treatment; pneumonia treatment; malaria prevention; malaria treatment; Integrated Management of Childhood Illness (IMCI); prevention of mother–to–child transmission of HIV; neonatal tetanus prevention; neonatal tetanus treatment; congenital syphilis prevention; congenital syphilis treatment; and primary health care. This yielded 380 articles.

In the second stage, titles and abstracts of these 380 articles were reviewed. Articles were then excluded if the target population was not infants under age one. This yielded 108 articles. Further exclusions were made if the article did not have an outcome directly related to neonatal health (knowledge about newborn illness, care seeking for newborn illness, utilization of postnatal care, or a neonatal health outcome related to nutritional status, morbidity or mortality). The final database for this sub–analysis included 93 articles. Articles were coded by the primary and secondary health condition addressed, the outcome variables, and categorized by the type and strength of study design.

All study designs were included, but were separated into three categories: randomized controlled trials (RCTs); non–randomized controlled trials; and observational and other non–experimental designs. We conducted descriptive analyses on the data set to present the proportion of beneficial health outcomes within each category. A table of only the RCTs is presented in Table S1 of **Online Supplementary Document**.

In this paper, when assessments selected for this analysis are specifically cited, we cite them with the first author's last name and year of publication, with the reference number in brackets with a prefix S. The full reference can be obtained from Appendix S2 in **Online Supplementary Document** where the full references for all the 93 assessments selected for the analysis in this paper can be located.

The term community health worker (CHW) is used here to refer to any community–level actor who receives training from the project or the broader health system/health program to assist in the activities of the project. We do not provide any further specification here regarding length of training, level of compensation (if any), formal recognition by the ministry of health, or other descriptive characteristics of CHWs, as they varied widely among the included assessments, although we recognize that this is an important dimension of these projects.

RESULTS

Description of database

As shown in **Figure 2**, South Asia was far more represented than Africa or Latin America for assessments of the effectiveness of CBPHC in improving neonatal health. The country with the most reported assessments was India (with 16), followed by Bangladesh (12), Nepal (12) and Pakistan (6). Brazil had 4 assessments; Ghana, Kenya, Tanzania and Uganda, each had 3. Two assessments were of projects in more than one country: one implemented in 10 African countries and one in four countries in sub–Saharan Africa and South Asia.

Most of the 93 assessments in our analysis were of projects that focused on a set of communities (n = 36) or a district (n = 42). Very few studies (n = 10) were at the provincial, national or multinational level, and 5 projects were implemented in one community only. Overwhelmingly, the projects were in rural areas (n = 67), although some were in urban (n = 19) or peri–urban areas (n = 7). Projects were mostly implemented by CHWs (n = 61), and many utilized ministry of health staff (n = 37), local field research-

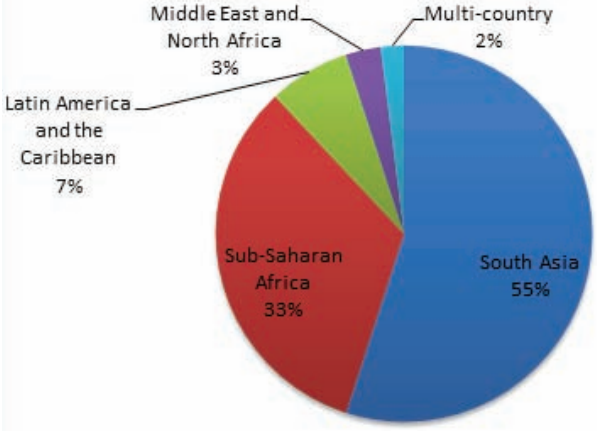

Figure 2. Regions of the world where projects were implemented whose assessments are in the neonatal database (n = 93).

ers (n = 26) and local community members (n = 27); these categories were not mutually exclusive and there are many projects using paid or volunteer CHWs who were a formal part of ministry of health services.

Interventions implemented

Three–quarters (76%) of the 93 assessments identified for this review described projects that implemented what were classified in the data extraction process as "neonatal/perinatal health" interventions. Almost one–third of the assessments (38%) described a breastfeeding intervention, and one–quarter (24%) described an intervention that focused on the prevention of low birth weight or the care of low–birth weight infants. Other common activities carried out by these projects included general primary health care, immunizations, micronutrient distribution, malaria prevention or treatment, tetanus prevention, pneumonia treatment, and tetanus prevention; no studies addressed pneumonia prevention or tetanus treatment (**Table 1**).

Projects were generally implemented over a relatively short timeline. One–quarter (24%) of the assessments were implemented for less than one year, and another three–quarters (72%) were implemented for between one to five years. Fewer than 5% of the projects in the review were implemented for more than five years.

Outcomes

The assessments utilized a range of methodologies. Almost half (46%) were randomized controlled trials (RCTs), and another 15% were quasi–experimental (non–randomized, controlled) trials. A fifth of the projects (21%) used an uncontrolled before–after study design, and a tenth (9%) used a descriptive study design. Other study designs less commonly used were case–control and cross–sectional studies. Table S1 in **Online Supplementary Document** provides a summary of the RCT assessments.

Among the 93 assessments included in our analysis, 45 separate indicators were measured. **Table 2** and **Table 3** list these and classify them in terms of the Donabedian scheme [11] of input, process, output, outcome and impact indicators and also in terms of the type of outcome. Outcomes were classified as either: (1) a significant positive effect, or (2) no significant effect or (3) a significant negative effect. Positive or negative effects were all statistically significant ($P \leq 0.05$). No significant effects were those in which statistical testing demonstrated a difference that was not statistically significant ($P > 0.05$), or significance testing was not performed. **Table 2** and **Table 3** provide an analysis of effectiveness in terms of one or more of the types of health indicators that were used in selecting assessments for inclusion in the review by specific health outcome or process/output indicator. A few process/output indicators shown in **Table 3** did not meet the criteria for inclusion in the review (eg, knowledge measures, quality of care measures, care seeking for neonatal illness, participation in group activities, or birth preparedness) but they were measured as part of project assessments along with other health outcome indicators that did qualify, so we have included them in **Table 3**.

Table 1. Interventions reported in assessments of community–based primary health care in improving neonatal health

Intervention	Number of assessments in review*	Percentage (n = 93)
General promotion of improved neonatal health	67	72.0
Promotion of breastfeeding during the neonatal period	33	35.5
Promotion of improved weight among neonates (including birth weight)	21	22.6
Primary health care	15	16.1
Integrated Management of Childhood Illness (IMCI)	14	15.1
Diarrhea treatment	12	12.9
Malaria treatment	12	12.9
Immunizations	11	11.8
Malaria prevention	7	7.5
Neonatal tetanus prevention	7	7.5
Pneumonia treatment	7	7.5
HIV/AIDS (prevention of mother–to–child transmission of HIV)	5	5.4
Congenital syphilis prevention	1	1.1
Congenital syphilis treatment	1	1.1

*The column sums to more than 93 since many assessments described multiple interventions.

Table 2. Assessments of community–based primary health care projects that document improvements in neonatal health as defined by health outcome and health impact indicators*

Outcome measure	Assessment methodology with findings						Total
	Randomized controlled assessments		Non–randomized controlled assessments		Observational (mostly pre/post intervention) assessments		
	Positive effect (n = 31)	No significant or negative effect (n = 12)	Positive effect (n = 8)	No significant or negative effect (n = 2)	Positive effect (n = 13)	No significant or negative effect (n = 7)	
Nutritional status:							
Birth weight/low birth weight	Christian 2003 [S23]	Larocque 2006 [S46]				Ahrari 2006 [S2]; Tielsch 2008 [S82]	4
Small–for–gestational age		Christian 2003 [S23]					1
Preterm birth	Christian 2003 [S23]						1
Morbidity:							
Neonatal sepsis	Gill 2014 [S34]; Soofi 2012 [S77]						2
Neonatal omphalitis	Mullany 2006 [S53]; Soofi 2012 [S77]						2
HIV mother–to–child transmission/infection rate					Gupta 2013 [S36]; Kagaayi 2005 [S40]	Vogt 2015 [S86]	3
Diarrhea/dysentery	Osendarp 2001 [S61]				el–Rafie 1990 [S31]	Tielsch 2008 [S82]	3
Acute respiratory infection	Datta 1987 [S27]					Tielsch 2008 [S82]	2
Mortality:							
Neonatal mortality rate	Bang 2005 [S13]; Baqui 2009 [S14]; Bhutta 2008 [S20]; Bhandari 2013 [S19]; El Arifeen 2012 [S30]; Fottrell 2013 [S33]; Kumar 2008 [S45]; Lewycka 2013 [S47]; Manandhar 2014 [S50]; Perry 2006 [S64]; Persson 2013 [S66]; Rahman 1982 [S68]; Tielsch 2007 [S81]; Tripathy 2010 [S83]	Azad 2010 [S9]; Colbourn 2013 [S24]; Gill 2014 [S34]; Kirkwood 2013 [S44]; More 2012 [S52]; Sloan 2008 [S76]; Soofi 2012 [S77]	Bang 1999 [S12]; Memon 2015 [S51]; Spencer 1987 [S78]	Singh 2014 [S74]	Rana 2011 [S69]		26
Early neonatal mortality rate			Memon 2015 [S51]	Singh 2014 [S74]			2
Perinatal mortality rate	Bang 2005 [S13]; Bhutta 2008 [S20]; Kumar 2008 [S45]; Jokhio 2005 [S39]		Bang 1999 [S12]; Memon 2015 [S51]		Seim 2014 [S72]		7
Early infant mortality rate			Christian 2004 [S22]				1
Infant mortality rate	Lewycka 2015 [S47]; Perry 2006 [S64]; Shankar 2008 [S73]	Benn 2008 [S18]; Sloan 2008 [S76]	Perry 2006 [S64]		Anand 2000 [S5]; Li 2007 [S48]; ASHA–India 2008 [S7]	Becker 1993 [S17]	9
Sepsis–specific case fatality rate					Khanal 2011 [S42]		1
Diarrhea–specific mortality						el–Rafie 1990 [S31]	1
Tetanus–specific mortality rate	Rahman 1982 [S68]	Newell 1996 [S59]			Becker 1993 [S17]; ASHA–India 2008 [S7]; Anand 2000 [S5]		5
Pneumonia–specific mortality rate					Bang 1994 [S11]		1
Low birth weight–specific mortality rate	Sloan 2008 [S76]; Tielsch 2007 [S81]						2
Total number of assessments	31	12	8	2	13	7	73

*See Appendix S2 in **Online Supplementary Document**.

Table 3. Assessments of community–based primary health care projects that document improvements in neonatal health as defined by health process/output indicators*

Process and output measures	Assessment methodology with findings						Total
	Randomized controlled assessments		Non–randomized controlled assessments		Observational (mostly pre/post intervention) assessments		
	Positive effect (n = 36)	No useful or negative effect (n = 5)	Positive effect (n = 28)	No useful or negative effect (n = 5)	Positive effect (n = 31)	No useful or negative effect (n = 5)	
Newborn care practices:							
Thermal care	Kumar 2008 [S45]; Findley 2013 [S32]	Sloan 2008 [S76]	Khan 2013 [S41]; Syed 2006 [S79]				5
Colostrum administration	Kumar 2008 [S45]		Khan 2013 [S41]; Memon 2015 [S51]	Malekafzali 2000 [S49]	Vir 2013 [S85]		5
Cord cleansing with chlorhexidine	El Arifeen 2012 [S30]; Mullany 2006 [S53]; Mullany 2013 [S54]; Soofi 2012 [S77]				Orabaton 2015 [S60]		5
Delayed bathing of the newborn within the first six hours after birth	Kumar 2008 [S45]; Penfold 2014 [S63]		Khan 2013 [S41]		Sitrin 2015 [S75]		4
Clean hygiene practices for home delivery	Fottrell 2013 [S33]; Kumar 2008 [S45]; Penfold 2014 [S63]		Memon 2015 [S51]; Khan 2013 [S41]		Parashar 2013 [S62]; Sitrin 2015 [S75]		7
Knowledge on newborn health:							
Knowledge of newborn danger signs	Findley 2013 [S32]		Khan 2013 [S41]		Callaghan–Koru 2013 [S21]; Dongre 2009 [S29]		4
Knowledge on early breastfeeding			Malekafzali 2000 [S49]				1
Knowledge on feeding during diarrhea episodes			Malekafzali 2000 [S49]				1
Feeding practices and micronutrient supplementation:							
Breastfeeding within the first two hours	Findley 2013 [S32]		Memon 2015 [S51]; Crookston 2000 [S26]; Syed 2006 [S79]	Malekafzali 2000 [S49]	Vir 2013 [S85]	Khan 2013 [S41]	7
Proper feeding during diarrhea episodes				Malekafzali 2000 [S49]			1
Exclusive breastfeeding	Bashour 2008 [S16]; Coutinho 2005 [S25]; Haider 2000 [S37]; Qureshi 2011 [S67]; Rotheram–Borus 2014 [S71]; Kimani–Murage 2015 [S43]; Lewycka 2013 [S47]		Balaluka 2012 [S10]; Crookston 2000 [S26]; Haider 2002 [S38]; Khan 2013 [S41]	Malekafzali 2000 [S49]	Neumann 1993 [S57]; Thiam 1995 [S80]	Khan 2013 [S41]; Neumann 1999 [S57]; Neutzling 1993 [S58]	17
Micronutrient supplementation coverage	Bang 2005 [S13]; Benn 2008 [S18]; Daulaire 1992 [S28]; Osendarp 2001 [S61]; Shankar 2008 [S73]	Christian 2003 [S23]				Tielsch 2008 [S82]	7
Referral and treatment of health conditions:							
Receipt of Amoxicillin within 24 h of onset of pneumonia symptoms					Murray 2014 [S55]		1

Table 3. Continued

Process and output measures	Assessment methodology with findings						Total
	Randomized controlled assessments		Non–randomized controlled assessments		Observational (mostly pre/post intervention) assessments		
	Positive effect (n = 36)	No useful or negative effect (n = 5)	Positive effect (n = 28)	No useful or negative effect (n = 5)	Positive effect (n = 31)	No useful or negative effect (n = 5)	
Referral of sick newborns	Ansah Manu 2014 [S6]	Bhutta 2008 [S20]	Baqui 2008 [S15]				3
Treatment of diarrhea with ORT					Thiam 1995 [S80]		1
Accuracy of assessments and adherence to protocols:							
Correct determination of low birth weight and very low birth weight by CHWs					Amano 2015 [S4]		1
Error free management of cases of pneumonia by traditional birth attendants			Perry 2016 [S65]				1
Correct interpretation of growth chart by mothers			Malekafzali 2000 [S49]				1
Detection/identification of sick newborns	Ansah Manu 2014 [S6]		Baqui 2008 [S15]		Rana 2011 [S69]		3
Adherence to protocols for management of LBW and VLBW					Amano 2015 [S4]		1
Health care utilization and birth preparedness:							
Antenatal care attendance	Persson 2013 [S66]		Uzondu 2015 [S84]; Baqui 2008 [S15]	Memon 2015 [S51]	Wangalwa 2012 [S88]; AFK– Pakistan 2014 [S1]; Rana 2011 [S69]		7
Delivery in a health facility or by a skilled birth attendant	Bhutta 2008 [S20]; Colbourn 2013 [S24]		Memon 2015 [S51]; Uzondu 2015 [S84]; Khan 2013 [S41]		AFK–Pakistan 2014 [S1]; Awoonor– Williams 2004 [S8]; Gopinath 2011 [S35]; Murray 2014 [S55]; Wangalwa 2012 [S88]		10
Receipt of postnatal care	Findley 2013 [S32]	Bashour 2008 [S16]			AFK–Pakistan 2014 [S1]; Wangalwa 2012 [S88]		4
Care seeking for neonatal illnesses	Bhandari 2013 [S19]; Ansah Manu 2014 [S6]			Ali 2005 [S3]	Murray 2014 [S55]; Nalwadda 2013 [S56]; Dongre 2009 [S29]		6
Immunization coverage	Rahman 1982 [S68]; Findley 2013 [S32]	Bashour 2008 [S16]	Memon 2015 [S51]		Becker 1993 [S17]; Nalwadda 2013 [S56]		6
Participation in group activities					Gopinath 2011 [S35]		1
Birth preparedness	Waiswa 2015 [S87]		Perry 2016 [S65]				2
Total number of assessments	37	5	28	6	31	5	111

ORT – oral rehydration therapy, LBW – low birth weight, VLBW – very low birth weight

*See Appendix S2 in **Online Supplementary Document**.

Overall, 31 of the 43 measurements of outcomes of randomized controlled assessments that are shown in Table 2 demonstrated positive effects: 2 out of 4 for nutritional status, 6 out of 6 for morbidity, and 24 out of 34 for mortality. Among the 10 measurements among non–randomized controlled assessments (all of which were mortality assessments), 8 out 10 demonstrated positive effects. Among the uncontrolled observational (mostly pre/post intervention) assessments, 13 out of 20 (65%) demonstrated positive effects.

This analysis indicates that, for a range of indicators, between 65–90% of the assessments included in our analysis observed a positive outcome or a favorable health impact. Among the 43 randomized controlled trials (RCTs), 31 (72%) showed a positive outcome and 12 (28%) showed either no effect or (in one case) a negative effect.

Of the 50 non–randomized and observational assessments included in our analysis (mostly pre/post intervention assessments), 13 out of 20 (65%) demonstrated a positive outcome. Similarly, for the health process/output measures shown in **Table 3**, the findings are strongly favorable. 37 out of 42 (88%) measurements among randomized assessments demonstrative positive effects, as did 28 out of 34 (82%) measurements among non–randomized controlled assessments and 31 out of 36 (86%) measurements among observational studies (which were mostly pre/post intervention assessments).

Table S1 in **Online Supplementary Document** provides details of the 43 randomized controlled trials included among our assessments.

Implementation strategies

A more detailed analysis of community–based implementation strategies for improving maternal, neonatal and child health is contained in another article in this series [12]. However, here we mention some of the findings that relate specifically to neonatal health interventions.

Key intervention implementation strategies that were utilized in CBPHC projects that improved neonatal health included: home visitation by CHWs for education in relation to prevention, recognition of danger signs, and early treatment/referral of neonates with serious illnesses; community–based treatment and early referral by CHWs for neonatal sepsis; outreach from health facilities, especially for antenatal care and maternal immunization against neonatal tetanus; and participatory women's groups (sometimes referred to as support groups) to raise awareness about healthy practices during pregnancy and for the newborn, and to raise awareness of danger signs for which facility–based care should be sought.

As shown in **Figure 3**, the most common associated implementation strategies were the training of CHWs (carried out in 75% of the projects) and the formation of women's support groups (present in 36% of the projects).

As shown in **Figure 4**, over half of the projects had stated goals and associated activities of promoting women's or community empowerment, forging links between the community and the health system and promoting local resource use. Less–commonly stated goals and activities were promotion of community leadership, adaptive learning and promotion of equity.

The data extraction form asked reviewers to subjectively judge whether the assessment observed any effect of community participation on health outcome and whether or not the outcome was positive. In 65% (60) of the 93 reports, community participation was reported to have had an effect, and in all of these

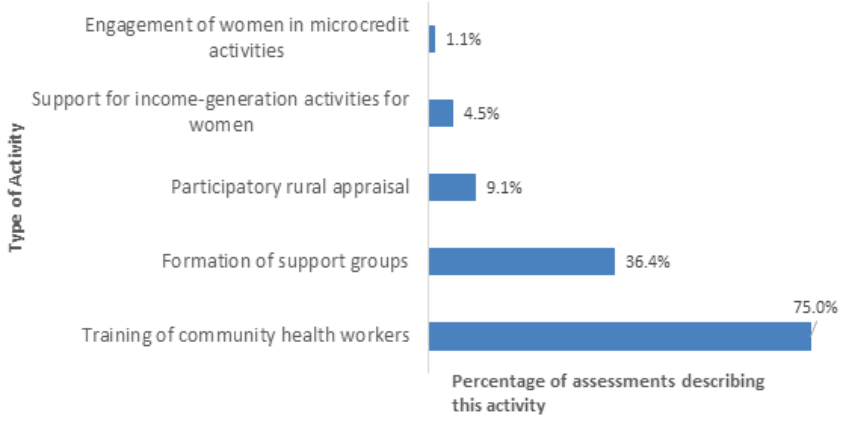

Figure 3. Common associated activities carried out in the implementation of CBPHC projects to improve neonatal health (n = 93). The sum is greater than 100% since some projects had more than one of these activities.

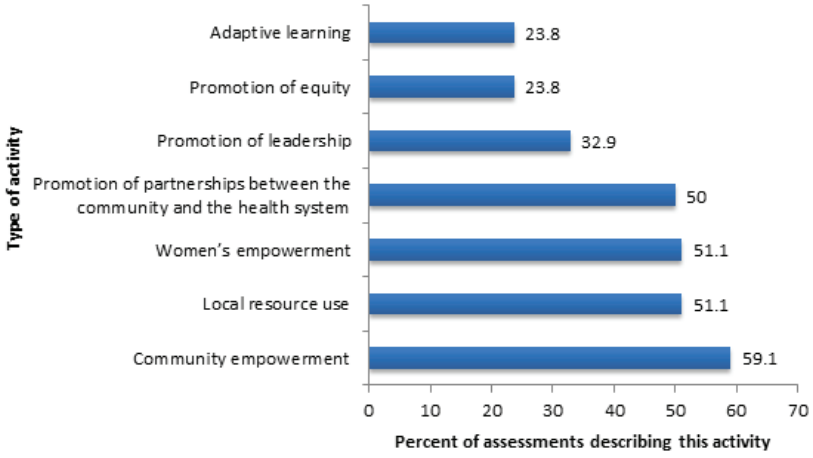

Figure 4. Common associated goals and activities carried out in the implementation of CBPHC projects to improve neonatal health (n = 93). The sum is greater than 100% since many projects employed more than one strategy.

cases the effect was judged to be positive. In over half (52%) of the 93 reports, the reviewers judged that the linkages between the community and the health system had an impact on health outcomes, and the effect on neonatal health was positive in almost all (93%) of these cases.

Equity

In terms of coverage, community–based efforts are generally designed to be more equitable than facility–based approaches in reaching those most in need and in improving the health of the most disadvantaged. This arises from the fact that community–based approaches contain strong outreach elements and are often able to reach those who have difficulties in accessing facility–based health care, whether because of distance or socioeconomic challenges such as cost or other barriers. The equity effects assessed among all the child health projects in our database are described elsewhere [13]. Here, however, we present the findings specific to neonatal health projects.

In total, 8 of the 93 assessments in our neonatal health review examined equity of health outcomes, using different categories of equity (income, geography, etc.). Of the 10 equity assessments reported for these 10 projects, 7 (70%) were considered to be "pro–equitable" (ie, the outcomes were more favorable for the newborns in the most disadvantaged households). For one equity assessment (10%), the outcome was considered to be "equitable" (ie, the outcome was equally favorable in the most disadvantaged and other households), and in only two equity assessment (20%) the outcomes were "inequitable" (ie, the outcomes were less favorable for newborns in the most disadvantaged households compared to other households) (**Figure 4**).

Table 4. Equity assessments of community–based primary health care in improving neonatal health*

Outcome of assessment	Outcome indicator	Equity category	Reference
Pro–equitable	**Mortality**		
	Neonatal mortality rate	Geography	ASHA–India 2008 [S7])
	Neonatal mortality rate	Geography	Bang 1999 [S12]
	Perinatal mortality rate	Geography	Bang 2005 [S13], Bang 1999 [S12]
	Postnatal care		
	Postnatal care coverage	Socio–economic status (including education)	Awoonor–Williams 2004 [S8]
	Skilled birth attendance		
	Skilled attendant at birth	Socio–economic status (including education)	Awoonor–Williams 2004 [S8]
	Breastfeeding		
	Exclusive breastfeeding from birth to 6 mo	Geography	Crookston 2000 [S26]
	Breastfeeding initiation within the first hour of life	Geography	Crookston 2000 [S26]
Equitable	**Mortality**		
	Tetanus neonatorum mortality rate	Geography	Newell 1966 [S59]
Inequitable	**Mortality**		
	Neonatal morality rate	Socio–economic status	Razzaque 2007 [S70]
	Breastfeeding		
	Exclusive breastfeeding from birth to 6 mo	Socio–economic status	Coutinho 2005 [S25]

*See Appendix S2 in **Online Supplementary Document**.

DISCUSSION

Our analysis provides strong evidence that CBPHC can improve neonatal health in low–income settings. Of the studies with strong experimental research designs, over 70% showed a positive neonatal health impact. Although many of these studies were smaller scale pilots or efficacy studies, it demonstrates that CBPHC can be an essential tool where access to facilities is limited and many births take place at home. In these settings, access to antenatal care is often limited; for example, only 49% of pregnant women in sub–Saharan Africa obtain four antenatal care visits [1]. Furthermore, among the 75 countries with the greatest burden of neonatal mortality, the median national coverage of interventions that are important for improving neonatal mortality is quite low: 65% for skilled attendant at delivery, 28% for postnatal visits for newborns, and 50% for early initiation of breastfeeding [14]. Community–based approaches will be essential for the near term in order to achieve universal coverage of health services for these mothers during their delivery and immediately following birth. Even if primary health care services are better developed and facility coverage of antenatal, delivery, and postnatal care increases, CBPHC can continue to make a contribution to improved neonatal health through promotion of healthy household practices and awareness of danger signs for which facility–based care should be sought.

The most common outcome indicators used in the assessments included in our analysis were related to population coverage of postnatal care and exclusive breastfeeding during the neonatal period; mortality was also relatively well–studied. While our review did not include assessments of the quality of implemented interventions or the degree to which projects were implemented under ideal vs more routine conditions (to assess to what degree the assessments were of CBPHC efficacy as opposed to effectiveness), we did summarize the findings by the rigor of the study design and demonstrated that for all levels of methodological rigor, CBPHC approaches appeared to produce favorable outcomes on neonatal health. It is worth noting the importance of assessing and improving the quality of care provided at the time of health contacts between patients and providers, whether they take place in facilities or in homes; however, information on this topic was missing in almost all of the assessments included in our analysis. Further, many of the studies with the strongest designs also had the most intensive support in carrying out the intervention, making it more difficult to judge the effectiveness if scaled up without focused attention or resources.

Our analysis reveals that many of the leading causes of death among children during the first month of life – especially those caused by infection – can be effectively addressed at the community level by CHWs if they have proper training and support. Home–based neonatal care includes promotion of immediate and exclusive breastfeeding, promotion of cleanliness, application of a topical antiseptic (chlorhexidine) to the umbilical cord, prevention of hypothermia, and early diagnosis and referral for treatment of neonatal sepsis. Strong evidence was found for the capacity of CHWs to promote clean delivery, especially in settings where births occur at home and hygiene is poor, to improve neonatal care practices at home, and to identify sick neonates in need of further care and treatment for certain conditions.

Given that many neonatal care projects utilize community health workers (CHWs), it is expected that many interventions can be provided close to or in the home, especially if CHWs live near their patients. Key community–based intervention strategies that were demonstrated to be successful in our analysis include home visitation by CHWs to educate mothers about healthy household practices, danger signs, the importance of early referral and treatment of neonates with danger signs, and outreach by mobile teams from health facilities (especially to provide maternal immunization against neonatal tetanus). Additionally, our analysis identifies the capacity of participatory women's groups to raise awareness about healthy practices during pregnancy and the postpartum/postnatal period, and to educate about danger signs for which facility–based care should be sought and the favorable effects of this approach for reducing neonatal mortality. Our equity analysis shows that almost all of the CBPHC interventions for improving newborn health benefit more disadvantaged groups to a greater degree than others.

This study had a number of limitations. The evidence is derived from projects mostly in rural South Asia. Most projects had a relatively short timeline and so we are unable to ascertain if they were successful in the long term. Furthermore, many (but not all) of the projects were implemented in relatively small populations under relatively ideal circumstances in which high–quality training, supervision, and logistical support were assured. So whether similar results can be achieved under more routine condition in larger populations over long periods of time is not known at present.

The large proportion of positive outcomes could be partially due to publication bias. Especially given that all study types were included (such as gray literature reports), there may have been a tendency by orga-

nizations to promote their successful work and only publish studies which had a beneficial impact. This study was further limited by the wide range of definitions, indicators and measurements used, which made standardization impossible. We aimed to provide useful categories and definitions, but the variation is wide. For example, it is known that the capacity and competence of CHWs varies widely; further analysis of the details regarding how CHWs were trained and deployed in the projects included in our review were limited. The context in which projects were carried out is also wide: details regarding exactly how the intervention strategies were carried out, and the specific conditions required for them to be effective at scale, go beyond the scope of this analysis. Finally, while this is intended to be a comprehensive review, the field is vast and some studies may not have been included.

The need to accelerate declines in neonatal mortality is readily apparent. In order to achieve universal health coverage and to end preventable neonatal deaths by the year 2030, basic and essential evidence–based neonatal health care interventions will need to reach all mothers and their newborns. Since many countries will not be able to provide universal coverage of essential newborn services by 2030 through facility–based services, progress in reducing neonatal mortality in high–mortality, resource–constrained settings will have to partially depend for the foreseeable future upon strengthening the types of interventions and approaches described here, and on improving timely referral to facilities for newborns with complications. The next step in this process is to test the types of interventions and approaches described here at scale using rigorous operations research methodologies. Further research is also needed in a wider variety of geographic areas, in urban and peri–urban settings, and for longer–term programs.

According to one recently published analysis based on modeling tools [2], immediately scaling up the currently available community–based interventions with evidence of effectiveness for reducing neonatal mortality to reach 90% population coverage would avert an estimated 740 000 neonatal deaths annually (27.4% of the total of 2.7 million neonatal deaths currently occurring each year). Similarly, a separate analysis [15] estimates that 700 000 newborn lives that would be saved if all of the community–based interventions gradually achieved a coverage of 90% over a 5–year period. While CBPHC approaches for reducing the number of stillbirths were not included in this review, there is growing evidence that community–based efforts to improve antenatal care, especially nutrition and malaria prevention, will have effects on the prevalence of stillbirth worldwide [15]. If the interventions that can be provided at primary health care centers and at hospitals but not in the community (eg, full supportive care for preterm newborns or treatment if very serious infection) were able to reach 90% of the neonates who need them, an additional 760 00 neonatal deaths could be averted (170 000 at primary health care centers and 0.59 million at hospitals) [2]. Thus, even though facility–based care is important for improving neonatal health, expanding the coverage of community–based services will also be essential in order to quickly accelerate the decline of neonatal mortality in high–burden countries.

CONCLUSIONS

The evidence regarding the potential of CBPHC to improve neonatal health in resource–constrained settings is strong. Now there is a need to begin to assemble evidence regarding the effectiveness of implementation of these interventions and strategies at scale. The scaling up of effective community–based interventions will be essential for accelerating progress in reducing neonatal mortality in the near term and for reaching universal coverage of evidence–based interventions for improving neonatal health. Based upon the current evidence, this will require the development and strengthening of a community–based platform involving (1) training and deployment of CHWs to visit homes frequently to promote healthy household behaviors, identification of neonates in need of referral, and utilization of health facilities appropriately, (2) formation and support of participatory women's groups, and (3) strengthening of outreach services provided by mobile health teams for provision of antenatal and postnatal care. Identifying ways for all newborns to receive the highest quality of care that can be provided in the home will have a sizable impact on neonatal mortality and morbidity worldwide.

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Conflict of interest: All authors have completed the Unified Competing Interest Form at www.icmje.org/coi_disclosure.pdf (available upon request from the corresponding author), and declare no conflict of interest.

REFERENCES

1 UNICEF. The State of the World's Children 2016: A Fair Chance for Every Child. 2016. Available: http://www.unicef.org/sowc2016/. Accessed: 25 April 2017.

2 Black RE, Levin C, Walker N, Chou D, Liu L, Temmerman M, et al. Reproductive, maternal, newborn, and child health: key messages from Disease Control Priorities 3rd Edition. Lancet. 2016;388:2811-24.

3 Oza S, Cousens SN, Lawn JE. Estimation of daily risk of neonatal death, including the day of birth, in 186 countries in 2013: a vital-registration and modelling-based study. Lancet Glob Health. 2014;2:e635-44. Medline:25442688 doi:10.1016/S2214-109X(14)70309-2

4 Baqui AH, Mitra D, Begum N, Hurt L, Soremekun S, Edmond K, et al. Neonatal mortality within 24 hours of birth in six low- and lower-middle-income countries. Bull World Health Organ. 2016;94:752-58B. Medline:27843165 doi:10.2471/BLT.15.160945

5 Liu L, Johnson HL, Cousens S, Perin J, Scott S, Lawn JE, et al. Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000. Lancet. 2012;379:2151-61. Medline:22579125 doi:10.1016/S0140-6736(12)60560-1

6 Black R, Laxminarayan R, Temmerman M, Walker N, editors. Disease Control Priorities: Reproductive, Maternal, Newborn, and Child Health, Third Edition. Washington, DC: World Bank; 2016.

7 Lassi ZS, Kumar R, Bhutta ZA. Community-based care to improve maternal, newborn, and child health. 2016. In: Disease Control Priorities: Reproductive, Maternal, Newborn, and Child Health. Washington, DC: World Bank. Available: https://openknowledge.worldbank.org/bitstream/handle/10986/23833/9781464803482.pdf?sequence=3&isAllowed=y. Accessed: 26 April 2017.

8 Bhutta ZA, Darmstadt GL, Hasan BS, Haws RA. Community-based interventions for improving perinatal and neonatal health outcomes in developing countries: a review of the evidence. Pediatrics. 2005;115:519-617. Medline:15866863 doi:10.1542/peds.2004-1441

9 Gogia S, Sachdev HP. Home-based neonatal care by community health workers for preventing mortality in neonates in low- and middle-income countries: a systematic review. J Perinatol. 2016;36 Suppl 1:S55-73. Medline:27109093 doi:10.1038/jp.2016.33

10 Perry H, Rassekh B, Gupta S, Wilhelm J, Freeman P. Comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 1. rationale, methods and database description. J Glob Health. 2017;7:010901.

11 Donabedian A. The quality of care. How can it be assessed? JAMA. 1988;260:1743-8. Medline:3045356 doi:10.1001/jama.1988.03410120089033

12 Perry HB, Sacks E, Schleiff M, Kumapley R, Gupta S. Comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 6. strategies used by effective projects. J Glob Health. 2017;7:010906.

13 Schleiff M, Kumapley R, Freeman P, Gupta S, Rassekh B, Perry HB. Comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 5. equity effects. J Glob Health. 2017;7:010905.

14 Victora CG, Requejo JH, Barros AJ, Berman P, Bhutta Z, Boerma T, et al. Countdown to 2015: a decade of tracking progress for maternal, newborn, and child survival. Lancet. 2016;387:2049-59. Medline:26477328 doi:10.1016/S0140-6736(15)00519-X

15 Chou VB, Friberg I, Christian M, Walker N, Perry HB. How many lives of mothers and children could be averted by strengthening community-based primary health care? An analysis using the lives saved (LiST) tool. J Glob Health. 2017;2:020401.

Electronic supplementary material:
The online version of this article contains supplementary material.

journal of global health

PAPERS

Comprehensive review of the evidence regarding the effectiveness of community–based primary health care in improving maternal, neonatal and child health: 4. child health findings

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Background This paper assesses the effectiveness of community–based primary health care (CBPHC) in improving child health beyond the neonatal period. Although there has been an accelerated decline in global under–5 mortality since 2000, mortality rates remain high in much of sub–Saharan Africa and in some south Asian countries where under–5 mortality is also decreasing more slowly. Essential interventions for child health at the community level have been identified. Our review aims to contribute further to this knowledge by examining how strong the evidence is and exploring in greater detail what specific interventions and implementation strategies appear to be effective.

Methods We reviewed relevant documents from 1950 onwards using a detailed protocol. Peer reviewed documents, reports and books assessing the impact of one or more CBPHC interventions on child health (defined as changes in population coverage of one or more key child survival interventions, nutritional status, serious morbidity or mortality) among children in a geographically defined population were examined for inclusion. Two separate reviews took place of each document followed by an independent consolidated summative review. Data from the latter review were transferred to an electronic database for analysis.

Results The findings provide strong evidence that the major causes of child mortality in resource–constrained settings can be addressed at the community level largely by engaging communities and supporting community–level workers. For all major categories of interventions (nutritional interventions; control of pneumonia, diarrheal disease and malaria; HIV prevention and treatment; immunizations; integrated management of childhood diseases; and comprehensive primary health care) we have presented randomized controlled trials that have consistently produced statistically significant and operationally important effects.

Conclusions This review shows that there is strong evidence of effectiveness for CBPHC implementation of an extensive range of interventions to improve child health and that four major strategies for delivering these interventions are effective.

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This paper concentrates on the effectiveness of community–based primary health care (CBPHC) in improving the health of children beyond the neonatal period. In 2015, the global mortality rate for children younger than 5 years of age (referred to hereafter as under–5 mortality) was 42.5 per 1000 live births, a decline from 90.4 per 1000 live births in 1990 [1]. Although

there has been an accelerated decline in global under–5 mortality since 2000, mortality rates remain high in much of sub–Saharan Africa and in some south Asian countries where under–5 mortality is also decreasing more slowly [1]. Following the neonatal period (when 45% of under–5 deaths occur currently), the major causes of mortality in children are pneumonia (26% of deaths in this age group), diarrhea (18%), and malaria (12%) [2]. Undernutrition is a cause of 45% of all under–5 deaths [3].

Essential interventions for child health at the community level have been identified as: promotion of breastfeeding and complementary feeding, supplementation with vitamin A and zinc, immunizations, co–trimoxazole for HIV–positive children, education on the safe disposal of feces and hand washing, distribution and promotion of insecticide–treated bed nets (ITNs) or indoor residual spraying (IRS) or both; detection and treatment or referral of children with severe acute undernutrition; and detection and treatment of pneumonia, malaria and diarrhea without danger signs and referral if danger signs appear [4]. It has been estimated that scaling up these interventions with an essential package of community–based interventions would avert 1.5 million deaths of children 1–59 months each year [1].

Our review aims to contribute further to this knowledge by examining how strong is the evidence for community–based primary health care (CBPHC) and exploring in greater detail what specific activities appear to be effective. Our concern is not just to strengthen the evidence about which interventions work at the community level but who does them and how, what conditions facilitate effectiveness, and what kinds of community–based approaches appear to be most effective. What characteristics do effective CBPHC activities share, and how strong is the evidence that partnerships between communities and health systems are required in order to improve child and maternal health?

The purpose of this paper is to summarize the evidence regarding the effectiveness of CBPHC for improving child health beyond the neonatal period.

METHODS

Our review aims to provide a comprehensive review of documents from 1950 onwards assessing the effectiveness of projects, programs and research studies (hereafter referred to as projects) using a detailed protocol. We examined peer–reviewed articles, reports and books assessing the impact of one or more CBPHC interventions on child health (coverage of a key evidence–based child survival indicator, nutritional status, serious morbidity, or mortality), among children in a geographically defined population. Two independent reviews were carried out and followed by an independent consolidated summative review. Data from the latter review were transferred to an electronic database for analysis. Data analysis took place using EPI INFO version 3.5.4 (Epi Info, US Centers for Disease Control and Prevention, Atlanta, Georgia, USA).

Only those assessments which had clear documentation of the intervention(s) and their impact on child health where included. Outcome measures included were changes in the population coverage of one or more evidence–based interventions; change in nutritional status (as measured by anthropometry, anemia, or assessment of micro–nutrient deficiency); change in the incidence or in the outcome of serious, life–threatening morbidity (such as pneumonia, diarrhea, malaria, and low–birth weight); and change in mortality (infant, 1–4 year, and under–5 mortality). Further details regarding the methodology are reported elsewhere in this series [5].

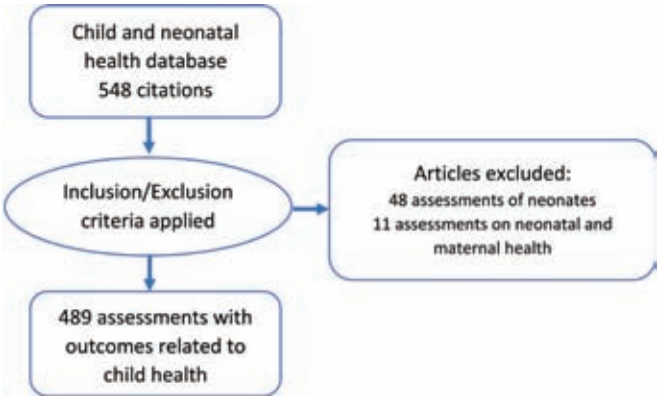

Figure 1. Flowchart of selection of assessments for child health review.

RESULTS

General findings

There were 548 assessments included in our database for neonates and 1–59 month–old children. The age of the study population was clearly documented as less than one month in 48 of these assessments. In another 12 assessments the intervention was found to focus on neonatal and maternal health. An analysis of these assessments is reported in the other papers in this series focusing on maternal and neonatal health and not reported here [6,7]. The remaining 489 assessments (**Figure 1**) focused pre-

dominately on children beyond the neonatal period, but many also include neonates. The complete bibliography of these assessments in contained in Appendix S1 in **Online Supplementary Document,** and are indicated in parenthesis with a prefix S throughout this paper.

Table 1 below lists the most common child interventions described in these 489 assessments. All but 5 of the 129 projects that were classified as providing "primary health care" also implemented one or more of the other interventions shown in **Table 1**. Some categories of child interventions had a relatively small number of assessments and so have been grouped as Other Interventions in **Table 1**. These Other interventions are not analyzed in detail in this paper. Other intervention categories not included above and included in the "Others" group in **Table 1** focused on trachoma prevention, tuberculosis, community organizations, financing, training and use of radios.

Table 2 shows the frequency of assessments according to the number of interventions implemented (not including "primary health care" and counting Integrated Management of Childhood Illness as one intervention). Although half (52%) of the assessments described projects with only one intervention and another quarter (21%) contained only two, one quarter contained three or more.

Below we provide an analysis of the interventions for children beyond the neonatal period grouped according to the categories listed in **Table 1**. The full list of studies reviewed and referred to in the parentheses in the text below can be found in Appendix S2 in **Online Supplementary Document**, where the assessments in our review that are cited here can be identified from the number in brackets in the text.

Table 1. Leading categories of child health interventions included in assessments

Intervention area	No.*	Percentage (n = 489)
Any nutrition–related activity (growth monitoring, breastfeeding promotion, complementary feeding promotion, or provision of micronutrients)	255	52.2
Diarrhea prevention or treatment	183	37.4
Diarrhea prevention and treatment	98	20.0
Diarrhea prevention only	48	9.8
Diarrhea treatment only	30	6.1
Malaria prevention or treatment	150	30.3
Malaria prevention and treatment	91	18.6
Malaria prevention only	27	5.5
Malaria treatment only	11	2.2
Immunizations	132	27.0
Primary health care	129	26.4
Integrated Management of Childhood Illness	110	22.5
Pneumonia prevention or treatment	108	22.1
Pneumonia prevention and treatment	46	9.4
Pneumonia prevention only	19	3.9
Pneumonia treatment only	40	8.2
HIV prevention or HIV/AIDS treatment	42	8.6
HIV prevention and HIV/AIDS treatment	13	2.7
HIV prevention only	24	4.9
HIV/AIDS treatment only	2	0.0
Other	24	4.9

*The sum of this column exceeds 489 since many assessments described more than one intervention.

Table 2. Number of intervention category areas among projects that focused on children beyond the neonatal period

Number of interventions per project	Frequency	Percentage (%)
1	243	51.6
2	97	21.3
3 to 4	76	16.6
5 to 7	49	10.5
Projects with interventions categorized as "Other"	24	4.9
Total	489	100.0

Table 3. Type of study methodology used among child health assessments

Type of study	Frequency	Percentage (%)
Randomized, controlled	177	36.6
Non–randomized, controlled	74	15.3
Uncontrolled, before–after	127	26.3
Case–control, cross–sectional	15	3.1
Cross–sectional	45	9.3
Descriptive	27	5.6
Non–study activity	24	4.3
Total	489	100.0

Table 3 outlines the types of study methodologies used for these 489 studies. One–half (52%) are controlled studies and one–quarter (26%) are uncontrolled, before–after comparisons. Other types of study methodologies make up the other quarter of assessments. These various study methodologies are spread fairly evenly across the major intervention categorical areas listed in Table 1 (data not shown).

Space limitations prevent us from a detailed analysis of all 489 assessments (as presented in Appendix S1 in **Online Supplementary Document**). We focus on those assessments that have the strongest study designs and greatest size of significant effects (these are presented in Appendix S2 in Online Supplementary Document). The remaining assessments in our review had similar effects unless otherwise stated.

Findings specific to pneumonia and diarrhea

Pneumonia is the leading single cause of under–5 mortality globally, accounting for 18% of deaths [2]. Diarrhea is a major cause of child mortality and morbidity globally and is responsible for 9% of deaths of children younger than 5 years of age [2]. Under the Integrated Global Action Plan for Pneumonia and Diarrhea (GAPPD), actions to address pneumonia and diarrhea are integrated according to a Treat, Protect and Prevent framework [8]. We will follow this framework in presenting our findings.

Treat

This part of the framework includes diagnosis, screening, triage and treatment. Our review includes five randomized controlled studies (RCTs) that all showed operationally important and statistically significant reductions in child mortality as a result of community health worker (CHW) treatment of pneumonia with antibiotics – reductions in the range of 13% to 60% [S1–5]. Throughout this article we will be referencing assessments from our database with numbers in brackets, preceded by an S prefix, to distinguish them from the references cited in the list of references at the end of this article. The number in brackets with an S prefix refers to the number of the assessment in Appendix S2 in **Online Supplementary Document**. Many other assessments – mainly non–randomized controlled, uncontrolled and case–control studies – also observed significant operationally important decreases in pneumonia–specific mortality in children aged less than 5 years, ranging from 28% to 69% [S6–11]. Two other RCTs demonstrated that CHWs can decrease the clinical severity of pneumonia significantly by treating respiratory infections at the community level through implementing good–quality case management [S12, S13]. Over 20 other studies showed decreases in child pneumonia–specific incidence or mortality but as their pneumonia case management was part of Integrated Management of Childhood Illnesses (IMCI) or Primary Health Care (PHC), they will be discussed under those sections below. Co–trimoxazole was the antibiotic most commonly used by CHWs in these studies.

Protect

Under this component are good health practices from birth: exclusive breastfeeding during the first six months of life, adequate complementary feeding, and vitamin A supplementation. Several RCTs demonstrated the efficacy of community–based vitamin A supplementation in reducing pneumonia mortality. In one, vitamin A supplementation decreased pneumonia–specific child mortality by 26% [S14]. In another study, the incidence of pneumonia was decreased through vitamin A supplementation by 44% [S15]. Zinc supplementation and promotion of hand washing provided by CHWs were each also found to significantly decrease the incidence of both pneumonia and diarrhea [S16, S17]. In one randomized controlled trial assessment, a community–based integrated nutrition program apparently not including vitamin A or zinc supplementation demonstrated a decreased incidence of pneumonia [S18]. Studies of vitamin A and zinc supplementation will be presented in more detail under the nutrition section below. Further studies have demonstrated the strong efficacy of zinc supplementation in reducing the incidence, severity and/or duration of diarrheal episodes in children [S19–24].

Prevent

This component includes vaccinations, hand washing with soap, safe drinking water and sanitation, reducing household air pollution, HIV prevention and co–trimoxazole prophylaxis for HIV–infected and

HIV–exposed children. Education of community members about diarrheal disease was a common activity carried out by trained CHWs, usually by visiting households or meeting with community groups. Randomized controlled trials found that community education focused specifically on the importance of proper disposal of animal feces from living areas produced decreases in the incidence of childhood diarrhea [S25, S26]. Randomized controlled trial assessments of education of caregivers about hand washing along with the provision of soap also decreased childhood diarrhea to an even greater degree than those mentioned in the previous sentence [S27–31]. Teaching mothers to use oral rehydration solution at home along with education about good household sanitation practices – whether by nurses working at the community level or by CHWs – was also effective [S32–34].

Purification of water within the household with sodium hypochlorite or another locally produced purifying agent was found effective in reducing childhood diarrhea in several studies [S35–38]. Solar sterilization of water was demonstrated as an effective approach to decrease the incidence of childhood diarrhea [S39–41]. Water filters such as BioSand and Lifestraw Family Filter that remove particulate matter were similarly effective in reducing the *E. coli* concentration in water and decreasing episodes of diarrhea [S42, S43]. The efficacy of community–based interventions concerning immunizations, HIV and nutrition are presented later in the respective sections.

Findings specific to malaria

Malaria is one of the three commonest causes of child mortality in those countries where it is endemic. In Africa, malaria is the cause of 15% of under–5 mortality [2]. Major community–based interventions for malaria prevention and treatment include: distribution of insecticide–treated bed nets (ITNs), household residual spraying, antimalarial treatment within the patient's household (HH) or in the community by CHWs, and intermittent preventive treatment (IPT) of malaria with anti–malarial medication. Community–based diagnosis of cases of malaria by CHWs may be based on clinical signs only or assisted by a rapid diagnostic test (RDT). **Table 4** presents illustrative randomized controlled trials from our database.

As shown in **Table 4**, there are now a number of randomized controlled trials of community–based interventions for malaria prevention and control that have shown operationally important programmatic effects, with some showing marked mortality impacts. These assessments demonstrate strong evidence of the effectiveness of community–based approaches to the prevention and control of malaria. The interventions presented include use of CHWs involved in house–to–house and group implementation strategies, treatment of malaria within the community by CHWs and mothers, engagement of women's groups, and malaria control provided by mobile teams from peripheral health facilities.

There were several other assessments that provided evidence in support of the community–based distribution of impregnated bed nets for prevention of malaria [S62–68]. A commonly used approach which produced operationally important outcomes was combining the distribution of ITNs with measles vaccination at the time of mobile clinic outreach sessions [S69–72]. Combining distribution of ITNs with malaria treatment was also effective [S73–75]. Several studies provided evidence that impregnated curtains have some effectiveness in reducing all–cause child mortality [S76, S77]. Some other studies focused on the use of ITNs but did not show as strong evidence individually [S78–83]. Studies which include prevention and treatment of malaria with Integrated Community Case Management of Childhood Illness (IMCI) or with other integrated approaches (such as Care Groups and Primary Health Care) will be presented later in this paper.

The assessments included in **Table 4** above present important aspects of the community–based treatment of malaria. Kidane et al. [S55], by showing that mothers in a remote area of Ethiopia (Tigray) with minimal training could decrease child mortality by diagnosing and treating malaria themselves, illustrated the importance of adapting interventions to local community circumstances as well as the importance of community capacity building. Other studies presented in **Table 4** provide good evidence that CHWs can diagnose and treat malaria in the community in association with the initial management of pneumonia in the same child at the same time [S57, S58]. Several other studies also demonstrated effective treatment of malaria by CHWs in the community alone or in combination with the treatment of concurrent diarrhea or pneumonia [S84–92].

While many of these studies of malaria treatment demonstrated a reduction in malaria–related morbidity or an improvement in CHW performance outcomes related to malaria, some demonstrated important decreases in overall child mortality as well [S93,94]. The cost-effectiveness of combining malaria and

Table 4. Randomized controlled trails of community–based malaria prevention and treatment projects focusing on children

Intervention	Type of outcome	Population size of study area	Specific outcome	Effect compared to control	Statistical significance	Reference number*
Distribution of impregnated bed nets with community education:						
Distribution with education	Mortality	5000–10 000 children in each arm	Mortality among children 1–7 y; mortality among children 1 mo–4 y; all–cause (1 to <5 y) mortality	Decreased by 25%; decreased by 18%; decreased by 33%	0.01; 0.05; 0.01	[S44], [S45], [S46]
Distribution with education	Mortality	2260 children 6 mo to <6 y	Malaria–specific mortality among children 1 to <5 y	Decreased by 30%	0.05	[S47]
Distribution with education	Coverage and mortality	Children in 160 villages	Percentage of children 0 to <5 y sleeping under an ITN; child mortality	Increased by 72%; decreased by 12%	0.01; 0.05	[S48], [S48]
Distribution with education	Coverage and morbidity	Children in 8 villages	ITN coverage to all households; *A. gambiensis* density	Increased by 99%; decreased by 99%	0.001, 0.001	[S49], [S49]
LLITN given plus training given to head of household	Morbidity	Children in 2015 households	Percentage of children 0 to <5 y with malaria	Decreased by 38%	0.05	[S50]
Distribution without education	Morbidity	219 children in 16 villages	Percentage of patients with fever	Decreased by 72%	<0.001	[S51]
Distribution with education (CHW going house to house)	Coverage	1400 children	Percentage of children sleeping under an ITN	Increased by 27%	0.05	[S52]
Community health network to support LLITN distribution	Coverage	11 villages	Percentage of total population using ITN at time of a 6–month follow up	Increased by 32% (in children 0 to <5 y)	0.001	[S53]
Education via CHW at HH level and community women's groups	Coverage	40 villages	Percentage of total population sleeping under an ITN	Increased by 49%	<0.001	[S54]
Community and household malaria treatment and prophylaxis:						
Treatment with chloroquine by mothers	Mortality	5385 children 0 to <5 y	All–cause child mortality	Decreased by 41%	0.003	[S55]
Training CHWs to treat malaria using an RDT	Accuracy of diagnosis	1457 children 0 to 15 y	Percentage of children treated unnecessarily with ACT	Decreased by 45%	0.001	[S56]
CHW treatment of malaria (based on RDT results), with AL (and also treatment with amoxicillin if symptoms of pneumonia present)	Morbidity	11 400 children 6 mo to <5 y	Percentage of febrile children who received AL; percentage of children diagnosed with pneumonia who received early appropriate treatment	Decreased by 77%; increased by 53%	<0.0001; <0.001	[S57], [S57]
CHW treatment of malaria with ACT (and also treatment with amoxicillin if symptoms of pneumonia present)	Morbidity	609 children 4–59 mo	Percentage of children receiving prompt and appropriate antibiotics	Increased by 34%	<0.001	[S58]
HH treatment of malaria (using an RDT) by CHW plus monthly IPT for 3 mo	Coverage of chemo–prophylaxis; morbidity	500 children 1–10 y (one–half also received IPT)	Incidence of RDT–confirmed malaria in HH + IPT group compared with HH– only group; coverage of children by 3 doses of IPT	Reduced by 85% (compared with HH only group); oncreased by 97%	0.01; 0.001	[S59], [S60]
IPT [Sulfadoxine–pyrimethamine at 3,9, and 15 mo (at time of routine immunization)	Coverage of chemo–prophylaxis	600 children 3 mo of age	Protective efficacy during the intervention period (among children 3–18 mo)	Increased by 22%	<0.0001	[S61]

ACT– Artemisinin combination therapy, AL– Artemether–lumefantrine, BCC– behavior change communication, CHW– Community health worker, IPT– Intermittent preventive treatment, HH– Household, ITN– insecticide–treated bed net, LLIN– Long–lasing insecticide–treated bed net, mo – month(s), RDT– Rapid diagnostic test, WAZ: weight–for–age Z score, WHZ – weight–for–height Z score, y – year(s)
*See Appendix S2 in **Online Supplementary Document**.

pneumonia treatment was studied. However, the findings were inconclusive [S95]. The demonstration of the capacity of CHWs to accurately diagnose malaria using RDTs is also an important finding [S56].

Table 4 also demonstrates the operational effectiveness of community–level IPT provided by CHWs [S59–61]. Several studies have demonstrated evidence of the important role that other members of the community can play in malaria prevention. School teachers, for instance, can provide IPT with a demonstrable impact on child mortality [S96]. However, the assessment reporting this result, although reporting significant operationally important outcomes, did not provide an adequate description of the intervention and therefore the finding needs to be interpreted with caution.

Trained traditional healers and drug vendors can effectively educate mothers about malaria prevention and early treatment [S97, 98]. Some other studies that focused on malaria treatment or IPT at the com-

munity level had results that were consistent with our findings above but the strength of evidence was not as strong [S99–111].

Findings specific to human immunodeficiency virus infection

There were fewer studies specifically on HIV/AIDS prevention and control at the community level. One study demonstrated that community–level treatment with co–trimoxazole of HIV–infected adults led to a reduction of 77% in the mortality of their originally HIV–negative, under–10 year–old household members. The provision of the drug and the monitoring of activities were provided by community members [S112]. Several studies reported on community–based HIV testing. One study found that among persons taking antiretroviral therapy, contacts that were visited at home were much more likely to undergo HIV testing than persons seen only at the health clinic [S113]. The prevention of mother–to–child transmission (PMTCT) was the most commonly studied HIV intervention in the assessments reviewed. As PMTCT is discussed in our maternal health paper, only a few examples will be mentioned here. In one study, the probability of survival of children to 18 months of age was 84% higher, compared to those in the control group, when HIV–positive mothers received antiretroviral medication as part of a comprehensive integrated program for HIV exposed infants [S114]. Household visits by CHWs, immunizations and growth monitoring were a part of this project.

The role of household visiting by CHWs was often found to be important for HIV–control projects. In one project, intensive follow–up care by CHWs at the homes of HIV–infected mothers led to much greater compliance with PMTCT and also with antenatal and postnatal care. Initiation of anti–retroviral therapy (ART) for HIV– infected infants was also earlier [S115]. Similarly, CHW home visiting was found to lead to a statistically significant 27% increase in identification of HIV–exposed and infected infants and attendance at health facilities [S116]. Community household visits by midwives who gave counseling and nevirapine to HIV–positive mothers and advised them to give nevirapine to their newborns within 72 hours of birth were found to decrease mother–to–child transmission of HIV by 60% [S117]. Community–based adherence support for 982 children on antiretroviral treatment was found to lead to 60% more children achieving virological suppression than children in the control group ($P=0.01$) [S118].

In many NGO–led child survival projects included in our review, education about HIV/AIDS with or without PMTCT was part of the project, along with many other interventions, and virtually all of them showed marked increases in knowledge about HIV infection.

Findings specific to immunizations

Immunizations against infectious diseases are well–established as an essential PHC intervention for child health. We have disaggregated the community–based assessments in our database under the areas of activity below.

Promotion and uptake through CHWs or others in routine systems

Community–based interventions involving CHWs reaching to the household level to promote participation in immunization activities and CHWs mobilizing communities have played a key role in producing high rates of population coverage for immunizations throughout the world. Peer education provided by CHWs visiting households, by community members recruited just for this purpose, by female community health education workers, and by members of mobile health teams coming from health facilities have contributed to greatly increased immunization coverage rates for children [S119–123].

Establishment of village networks of trained traditional birth attendants and female CHWs was effective. These CHWs promoted immunizations, use of health facilities, and household diarrhea management with oral rehydration solution (ORS) and also carried out growth monitoring of children. Their activities led to a 150% increase in the coverage of 12–23 month–old children with full immunization [S124].

Village–level approaches to community mobilization

Promotion of community participation through education of village leaders, teachers, and extension workers (who in turn educated community members) was found effective, increasing full immunization completion coverage levels by 50% [S125]. Mass media using TV, radio, newspapers and leaflets, distributed and explained by community–level workers, significantly increased community awareness about immunizations with mothers. Those mothers who had increased awareness were much more likely to take their

children to be vaccinated [S126]. In Lao PDR, community–based workshops promoting attendance for vaccination significantly increased all childhood vaccinations [S127].

Promotion of immunizations through microcredit programs

A case–controlled study of community health education campaigns associated with microcredit programs were found to greatly increase fully immunization coverage [S128].

Health Days

National Immunization Days, in which community mobilization and immunization at peripheral service points followed up by immunization at the household for those who did not come to the service point led to significant decreases in the incidence of acute flaccid paralysis [S129]. Annual vaccination weeks with household visits by CHWs increased vaccination completion rates from 30% to 53% [S130].

Household vaccination strategies

A case–controlled study of peer education provided by CHWs visiting households, promoting community involvement, and providing immunizations, vitamin A supplementation and growth monitoring led to not only to greatly increased immunization coverage but also to a 58% decrease in under–5 mortality compared to controls [S131]. House–to–house administration of polio vaccine significantly increased polio vaccination rates [S132].

Findings specific to nutrition

Undernutrition contributes to 45% of under–5 mortality globally [3] and therefore is a major concern. In this section our review findings will be categorized into four areas: protein–energy undernutrition (usually assessed by anthropometry), breastfeeding (BF), complementary feeding (CF), and micronutrient supplementation.

Protein–energy undernutrition

Table 5 presents the findings from randomized controlled and non–randomized controlled studies with statistically significant and operationally large effects compared to controls with protein–energy undernutrition. **Table 5** demonstrates that undernutrition can be addressed successfully at the community level through health education involving CHWs visiting households, regular monitoring of child growth in the community, and supplementation with ready–to–use therapeutic food (RUTF). Albendazole supplementation to mothers also was found to have an important effect on child growth. Even for depressed mothers with HIV, well–organized programs improved the nutrition of their children. Group learning programs associated with small loans (that may have enabled mothers to obtain more nutritious foods for their children) also improved child nutrition. Many other integrated programs were also demonstrated to contribute to good child nutrition. These will be covered below in the final section on integrated programs.

Other controlled interventions with smaller effect sizes and statistically significant results at the $P<0.05$ level also were very informative. In Vietnam, among children aged less than 15 months with a weight–for–age Z score of <–2, the Hearth approach along with de–worming significantly improved growth when compared to controls who received only deworming [S143]. The Hearth approach is a process of identifying local "positive deviant" women who have well–nourished children. Mothers of malnourished children are also identified and they are guided through a process of learning how positive deviants care and feed their children and applying this knowledge in the care of their own children through hands–on cooking sessions using locally available foods [S143].

In a non–randomized controlled project that was implemented over a five–year period, the hypothesis was tested that younger siblings of older children with severe undernutrition whose undernutrition had been overcome using the Hearth approach should have better nutrition than similar children whose mothers had not been exposed to the Hearth program. Outcomes were compared for 10 different 3–month age groupings of younger siblings (6–8, 9–11, 12–14, etc.). For younger siblings whose older sibling had been severely malnourished and whose mother had been exposed to the Hearth approach (the intervention group), the younger sibling mean weight for age Z score was always higher than the older sibling ($P=0.005$ or less in all age groups). For the control group (children with an older sibling who had been moderately malnourished, mildly malnourished, or of normal weight and whose mother had not been

Table 5. Studies of community–based interventions addressing protein energy undernutrition

Intervention	Type of outcome	Population size of study area	Specific Outcome	Effect compared to control	Statistical significance	Reference number*
Randomized controlled assessments:						
Home–based distribution of RUTF for children with severe acute, malnutrition	Change in nutritional Status	1178 10–60–mo–old malnourished and wasted children	Attainment of WHZ≥2 without edema or relapse	Increased by 33%	0.001	[S133]
Education plus micronutrient–fortified milk–based cereal household supplementation	Change in nutritional status	104 infants each in 3 different groups [Supplementation only, counselling only, and control)	Percentage of children with a mean weight gain of 250 g or more	14% more (in supplemental group compared to control group)	0.01	[S134]
Nutrition and hygiene education with growth monitoring at community level	Change in nutritional status	Children 0 to <5 y from 55 randomly selected households	Mean WAZ in older children, mean WAZ in younger children	Increased by 10%; Increased by 36%	0.05; 0.001	[S135]
Albendazole 600 mg every 6 mo provided at household level	Change in nutritional status; morbidity	610 children 18 mo of age who were treated for two years	Prevalence of stunting; prevalence of fecal worms	Decreased by 9%; Decreased by 14%	0.001; 0.001	[S136]
Home visits by CHWs to reduce alcohol use, promote BF, child nutrition, and perinatal HIV regimen compliance	Change in nutritional status	644 depressed mothers and their children 0 to<6 mo	Mean LAZ scores for children 0 to <6 mo	Increased by 7%	0.034	[S137]
Paraprofessional home visits with provision of health education about BF, child nutrition, HIV, PMTCT, and mental health	Change in nutritional status	24 township neighborhoods	Mean WHZs for children	Increased by 19%	0.001	[S138]
Non–randomized controlled interventions:						
Home visits from community health agent facilitators to provide education and monthly growth monitoring	Change in nutritional status	14 374 children, 0 to <5 y	Undernutrition in children 0–35 mo	Decreased by 27%	0.05	[S139]
Albendazole 400mg distributed to households with mothers at 12 and 23 weeks of pregnancy	Change in nutritional status	4998 mothers and their children, 0 to<6 mo	Mortality rate in infants during their first 6 mo of life	Decreased by 41%	0.01	[S140]
Using CHWs in a nutritional demonstration (Hearth) program (mothers are trained by participation in cooking nutritious food for children)	Change in nutritional status	1200 children, 3–48 mo	Percentage of children with normal weight for age; percentage of children with severe undernutrition	Increased by 10%; decreased by 18%	0.02; 0.02	[S141], [S141]
Facilitated group learning sessions on maternal and child health with small loans given to mothers	Change in nutritional status	200 children 0 to<3 y	Mean HFA children 12 to 24 mo	Increased by 48%	0.01	[S142]

BF – breastfeeding, HFA – height for age, HIV – human immunodeficiency virus, LAZ – length–for–age Z score, mo – month(s), PMTCT – prevention of mother–to–child transmission, RUTF – ready–to–use–therapeutic food, WHZ – weight–for–height Z score, y – year(s)
*See Appendix S2 in **Online Supplementary Document**.

exposed to the Hearth program) the same comparison with younger siblings was carried out. The mean weight for age Z score of the younger siblings was always lower for mildly malnourished and normal weight children than their older sibling ($P<0.05$ for all but one age group, 6–8 months). This study provides evidence regarding the wider family effects of nutritional education [S144]. However any conclusions need to be guarded due to the limited size of the populations studied. These results would need to be repeated in further similar studies.

The benefits of promotion of agriculture and voucher programs on childhood nutrition have also been demonstrated. In a population including 130 000 children younger than 5 years of age in Nepal, promotion of increased household production of food through training Village Model Farmers, and subsequently village women, led over a 2–year period to a decrease of 10% in the prevalence of underweight in children aged 0 to 4 years [S145]. A community development and livestock promotion project in Nepal for 307 children produced similar results. Although the results in the latter study were not statistically significant after 2 years, the intervention group was more likely to have indoor access to water, treat their water and have a latrine. Longer participation in the program was strongly associated with a better mean height–for–age score ($P<0.00001$) [S146].

Giving vouchers to mothers along with health education and a community household health package was found not to result in statistically significant improved child nutrition in the short term but if the program

for those children was extended for 2 years more until the children were aged 8 to 10 years, then the mean height for weight Z scores of these children increased by 23% ($P=0.029$) compared to controls of the same age [S147]. Other studies demonstrated a statistically significant association of mothers receiving vouchers with greater use of nutrition monitoring at the community level and improved nutrition of their children [S148–151].

Breastfeeding and complementary feeding

Exclusive breastfeeding (BF) during the first 6 months of age with continued BF through the first two years of life is an important contributor to good childhood nutrition, reduced morbidity, and improved mortality in resource–constrained settings. Promotion of exclusive breastfeeding for the first 6 months of life has been estimated to be one of the most effective preventive strategy for saving the lives of young children in low–income settings [9]. Complementary feeding (CF) to supplement breastfeeding is needed from 6 months of age onwards for children to sustain normal growth. Findings from randomized and non–randomized controlled community–based assessments included in our review are presented in **Table 6**.

The data from **Table 6** indicate that exclusive breastfeeding can be effectively promoted at the community level by CHWs, by trained home peer counsellors, by community outreach health professionals from the nearest health facility, and by mothers' community health clubs. Of note is that the strongest effects were found when the CHWs and home peer counselors rather than more highly trained health professionals reaching out from local health facilities were doing the education. Education about complementary feeding was found to produce statistically significant improvements in mean height and weight. The Hearth approach mentioned in the section on protein energy undernutrition was also found to be effec-

Table 6. Community–based projects that promoted breastfeeding and complementary feeding in children

Intervention	Type of outcome	Population size of study area	Specific outcome	Effect compared to control	Statistical significance	Reference number*
Randomized controlled interventions						
Breastfeeding:						
Training of 1 CHW per village to promote exclusive BF	Change in health–related practice	1115 mothers and their children 0 to <6 mo	Percentage of children exclusively breastfed to <6 mo of age	Increased by 38%	0.05	[S151]
Home counselling by trained CHWs	Change in health–related practice	1597 mothers and their children, 0 to <6 mo	Percentage of children exclusively breastfed to <6 mo of age	Increased by 63%	0.001	[S152]
Home visits by trained women during the postnatal period	Change in health–related practice	175 mothers and their children 0 to <6 mo	Percentage of children exclusively breastfed to <6 mo of age	Increased by 16%	0.001	[S153]
Peer counsellors from community educated pregnant mothers in breastfeeding	Change in health–related practice	726 pregnant women and their children 0 to <6 mo	Exclusive breastfeeding, to <6 mo of age	Increased by 64%	0.01	[S154]
Complementary feeding:						
CHW education of mothers about CF during home visits	Change in nutritional status	118 infants	Prevalence of stunting	Decreased by 10%	<0.05	[S155]
Non–randomized controlled trials:						
Training of mothers in essential nutrition by community outreach workers	Change in health–related practice	320 infants 0 to <6 mo in 8 districts	Percentage of children exclusively breastfed until 6 mo of age	Increased by 22%	0.001	[S156]
Provision of fortified CF at households along with education by CHWs	Change in nutritional status	Children 9–14m in the catchment areas of 10 health clinics	Odds of being underweight after being enrolled in the program for one year	Decreased by 75%	0.007	[S157]
Uncontrolled before–after studies:						
Formation of community health clubs and provision of health education by CHWs	Change in health–related practice	1000 children 0 to <5 y and their mothers	Early initiation of BF; Exclusive BF in children 0–6 mo	Increased by 50%; increased by 60%	0.001; 0.001	[S158], [S158]
Hearth program, CF education by CHWs, nutrition revolving fund established to aid mothers to buy chickens to provide protein for children plus small income	Change in nutritional status	1700 children 0 to <3 y	Prevalence of normal WFA children; prevalence of severe malnutrition	Compared to baseline, increased by 13%; decreased by 17%	0.001; 0.001	[S159], [S159]

BF – breastfeeding, CF – complementary feeding, CHW – community health worker, mo – month(s), WFA –weight for age, y – year(s)

*See Appendix S2 in **Online Supplementary Document**.

tive in undernourished children younger than 15 months of age, in the study cited in **Table 5** [S141], and in other studies with similar results [S143, S159, S160].

Micronutrient supplementation

Types of micronutrient supplementation that were included in projects whose assessments qualified for our review included vitamin A, zinc, iron and multivitamins. **Table 7** contains details about randomized and non–randomized controlled studies that have been included in this review and that have operationally important effects.**Table 7** shows that vitamin A supplementation provided at the household level to mothers, to newborns, and especially to children 6–59 months of age leads to decreased child mortality. Even fortifying market monosodium glutamate with vitamin A leads to a decrease in the rate of xerophthalmia (a condition of eye dryness and eventual scarring produced by vitamin A deficiency) and all–cause child mortality. It also decreases child mortality from pneumonia and measles.

Daily zinc supplementation decreased all–cause mortality in children 12–48 months of age, but not to the same extent as vitamin A. A decrease in the incidence of diarrhea in children receiving zinc has also been demonstrated in other controlled studies [S174, S175]. Of particular note is that in one study of children 1 to <6 months of age in a malaria–prone area, the risk of death or severe morbidity increased significantly in those who received iron supplementation [S176]. While other studies in non–malaria–endemic areas confirmed the value of iron supplementation for treating anemia, this finding provides reason for caution in providing iron supplementation to children aged 1 to <6 months of age in malaria–endemic areas.

Findings specific to integrated approaches to child health

Children present with a variety of common diseases even when one disease such as malaria may predominate in a particular area. Undernutrition is a common risk factor for childhood infections [10,11]. Opportunities to update immunization status need to be taken at every opportunity to prevent serious childhood infections. Mothers may lose confidence in CHWs and CHWs may lose confidence in themselves if CHWs have to turn patients away because they can only deal with one disease entity (or if they do not have the capacity to treat any illnesses). Therefore, for the most cost–effective and efficient use of resources and for increasing the confidence of mothers in CHWs and CHWs in themselves, it is important that services provided be integrated as much as practical for the benefit of all. To do this, a range of integrated approaches have been developed at the community level, and available assessments of the projects have been included in our review.

Integrated Management of Childhood Illness (IMCI) and Integrated Community Case Management (iCCM)

Integrated Management of Childhood Illness (IMCI) integrates the prevention and treatment of all childhood illness at health facilities. Its community component, called Community IMCI (or C–IMCI), usually consists of preventive activities and early recognition of potentially serious acute illness that can be performed in the community by trained CHWs going door–to–door and meeting with groups, usually without treatment of illnesses other than ORS for diarrhea. CHWs are taught to recognize children with danger signs and refer or even escort patients to the nearest health facility for treatment. CHWs also facilitate outreach activities from the local health center such as immunizations.

Integrated Community Case Management (iCCM) enables CHWs to diagnose and treat serious acute illnesses of childhood (acute respiratory infection, diarrhea, malaria and in some cases acute malnutrition).

For iCCM to be effective, CHWs need to be well–trained, to have the confidence and support of their community, to be well–linked to their local health facility staff for referral of patients, to receive regular supervision to maintain their skills, and to be well–supplied with the drugs and equipment necessary to perform their tasks [12]. These CHWs often also have community health education roles, perform household visiting, and may also be responsible for such activities as promotion and distribution of ITNs. Studies of IMCI and iCCM are often concerned with maintaining the quality of all the above tasks. **Table 8** summarizes the findings of assessments of C–IMCI and iCCM interventions.The studies described in **Table 8** show that iCCM can be implemented successfully at the community level and indeed may lead to a decrease in under–5 mortality. A large assessment of children younger than 5 years of age in 15 districts in Rwanda with complete mortality data further supports this. This assessment found that the number of children receiving community–based treatment for diarrhea and pneumonia increased significantly in the

Table 7. Studies of micronutrient supplementation at the community level

Intervention	Type of outcome	Population size of study area	Specific outcome	Effect compared to control	Statistical significance	Reference number*
Randomized controlled interventions:						
Vitamin A supplementation:						
Supplemental vitamin A 8333 IU weekly and E at the household level	Mortality	7764 children, 0 to <5 y	Risk of death in girls; risk of death in boys	Decreased by 59%; Decreased by 48%	0.01; 0.04	[S161], [S161]
Maternal vitamin A 3330 IU daily and folate supplementation	Mortality	3389 pregnant women and children	Perinatal, and neonatal mortality	Decreased by 20%	0.01	[S162]
Vitamin A (200 000 IU for 12–59 mo–old children, 100 000 IU for 6–11 mo–old children, and 50 000 IU –5m) in a single dose	Mortality	3786 children, 0 to <5 years	1–59 mo mortality	Decreased by 26%	0.05	[S14]
Vitamin A every 4 mo (60 000 IU)	Mortality	28 630 children, 6–72 mo	1–59 mo mortality; case fatality rate for measles	Decreased by 30%; decreased by 76%	0.05; 0.001	[S163], [S163]
Vitamin A 200 000 IU every 6 mo for 18 mo	Morbidity	12 109 children, 9–72 mo	Incidence of night blindness	Decreased by 50%	0.001	[S164]
Vitamin A 200 000 IU for 12–59 mo–old children and 100 000 IU for 1–11m–old children every 4 mo	Mortality	9200 children, 0 to <5 y	1–59 mo mortality	Decreased by 19%	0.05	[S165]
Vitamin A 60 000 IU every 4 mo	Mortality	28 630 children, 6–72 mo	1–59 mo mortality in females	Decreased by 90%	0.0001	[S166]
Vitamin A 200 000 IU for 1–3 mo–old children at 1–3 mo of age and again 6–8 mo later	Mortality	25 000 children, 0 to <5 y	1–59 mo mortality	Decreased by 34%	0.01	[S167]
Infants received 24 000 IU of vitamin A on days 1 and 2 after delivery	Mortality	5786 newborns	Mortality during the 1st 6m of life	Decreased by 22%	0.02	[S168]
Vitamin A given at birth (50 000 IU)	Mortality	7953 newborns	All–cause infant mortality	Decreased by 15%	0.045	[S169]
Vitamin A 200 000 IU for 12–59 mo–old children and 100 000 IU for 1–11 mo–old infants	Morbidity	1405 children, 6–47 mo	Incidence of acute respiratory infection in normal children.	Increased by 8%	0.05	[S170]
Vitamin A 200 000 IU for 12–59 mo–old children and 100 000 IU for 1–11 mo– old infants twice a year and accompanied by nutrition education	Change in nutritional status	720 children 0–36 mo	Prevalence of stunting	Decreased by 11%	0.01	[S171]
Zinc supplementation:						
Vitamin A 200 000 IU as one dose plus 10 mg zinc 6 days a week	Morbidity	148 children, 6–72 mo	Prevalence of malaria	Decreased by 32%	<0.001	[S172]
Zinc (70 mg) weekly for one year	Morbidity	809 children, 6–18 mo	Incidence of pneumonia	Decreased by 44%	0.01	[S83]
Daily supplementation with 10 mg of zinc	Mortality	21 274 children, 12–48 mo for 485 days	Relative risk of all–cause mortality in children 12–48 mo	Decreased by 18%	0.045	[S173]
Daily supplementation with 10 mg of zinc	Morbidity	854 children 6–48 mo	Incidence of diarrhea in children 0 to < 2 y	Decreased by 25%	0.001	[S174]
Zinc 20mg zinc daily for 15 d (for children with diarrhea)	Morbidity	139 children 6–35 mo	Duration of persistent diarrhea	Decreased by 28%	0.01	[S175]
Iron supplementation:						
Iron, folate and zinc supplementation: iron (12.5 mg), folic acid (5 µg) zinc (10mg) daily	Morbidity	Children, 1 to <6 mo	Risk of severe morbidity (from severe malaria) and death in groups that received iron	Increased by 12%	0.02	[S176]
Sale to households of "Sprinkles" (a powder to sprinkle on top of food) containing iron and B vitamins	Morbidity	561 children, 0 to <5 y	Prevalence of anemia	Decreased by 19%	0.001	[S177]
Daily home fortification with micronutrient powder containing iron for 2 mo	Change in nutritional status	1103 children, 0 to <5 y	Mean hemoglobin concentration	Increased by 7%	0.001	[S178]
Multivitamin and mineral powder (MMP) supplement: 2 sachets 2 times a week (compared to 2 sachets MMP daily and controls)	Morbidity	115 children, 0 to <5 y in each of the 3 groups	Prevalence of anemia, compliance with MMP supplement	Decreased by 32% in daily MMP; 200% greater in 2 times a week group compared to daily	0.001; 0.001	[S179]
Non–randomized controlled interventions:						
Vitamin A supplementation:						
Fortification of monosodium gluconate sold in markets with vitamin A	Morbidity	5755 children 0 to <5 y	Prevalence of Bitot's spots; mortality	Decreased by 600%; mortality rate among pre–school children in the control villages was 1.8 times greater than that for children in intervention villages	0.0001; 0.001	[S180], [S180]
Education on weaning practices, Vitamin A provision to children, Provision of iron to mothers, immunization, door–to–door visits from CHWs	Mortality	6663 children, 0–35 mo and 14 551 women	All–cause mortality among children 6–35 mo; pneumonia–specific mortality among children 6–35 mo	Decreased by 32%; decreased by 53%	0.001; 0.001	[S181], [S181]

1–year period after iCCM implementation, from 0.83 cases/1000 child–months to 3.80 cases/1000 child–months ($P<0.001$) and from 0.25 cases/1000 child–months to 5.28 cases/1000 child–months ($P<0.001$), respectively. On average, total under–5 mortality rates declined significantly by 38% ($P<0.001$), and health facility use declined significantly by 15%. These decreases were significantly greater than expected based on baseline trends [S192].

In many parts of rural Uganda with limited access to trained health staff, up to 50% of cases of childhood illnesses are managed by drug sellers. One study in which private drug sellers were trained to treat patients using iCCM protocols revealed a strong adherence to the iCCM protocol in terms of testing, examining and treating children. On follow up evaluation after training, 88% of children diagnosed with diarrhea received ORS. 88% of children presenting with a fever received a RDT for malaria and 94% of children who were diagnosed as RDT–positive received artemisinin combination therapy. Of those who were diagnosed with pneumonia, 91% of them received amoxicillin treatment. Overall performance (defined as correct treatment) showed a 27% ($P=0.001$) increase compared with baseline levels [S188]. The other studies cited in **Table 8** demonstrate that monthly community–level supervision by trained supervisors from the local health facility can lead to maintenance of CHW skills in iCCM diagnosis and treatment and that iCCM leads to more children receiving treatment for these common illnesses [S186, S189–191].

Care Groups

Care Groups were included in the review through the publication of the results of the evaluation of several projects. A Care Group is a group of 10–15 community volunteers who act as community–based health educators. The Care Group meets every two weeks with a project facilitator for two hours or so to learn some new education messages. Each volunteer is responsible for regularly visiting 10–15 of her neighbors, sharing the new messages they just learned. With this structure and basic approach, scaling up is readily possible [13,14].

In a 5–year Care Group project in Sofala Province in Mozambique, the project area was divided into two sub–areas (A and B) since project activities began several years later in Area B after activities in Area A had begun. Major improvements were achieved across most indicators of child health comparing baseline with endline findings. Key outcomes were that the overall proportion of children with undernutrition (WAZ<–2.0 SD) decreased by 6% in Area A and by 10% in Area B; insecticide–treated bed net (ITN) use increased by 45% in Area A and by 71% in Area B; rates of exclusive breastfeeding increased by 60% in Area A and 25% in Area B; the percentage of children 9–23m of age who ate three or more meals per day increased from by 42% in Area A and by 20% in Area B. Based on findings obtained with the Lives Saved Tool (LiST), the project saved an estimated 6848 lives and the cost per life saved, the cost per disability–adjusted life year (DALY) averted, and the annual cost per beneficiary were US$ 441, US$ 14.72 and US $2.78, respectively [S193].

Another Care Group project in the rural part of the Chokwe District in Mozambique also incorporated a community–based vital events registry system as part of the activities of the Care Groups. The assessment of this project demonstrated not only the efficacy of Care Groups but also the quality of a community–based vital events registration system. This assessment demonstrated that the Care Group approach resulted in a 49% decrease in the infant mortality rate and a 42% decrease in the under–5 mortality rate over the five year period of project implementation, confirmed by an independent retrospective morality assessment based on maternal birth histories [S194]. Similar results were found in another Care Group project in our database in Burundi [S195].

Integrated community–based primary health care (CBPHC)

Primary health care (PHC) includes the provision of a comprehensive range of essential preventive and treatment actions aimed at meeting all the common health needs of community members (especially those of women of childbearing age and children but also of men and older women) using practical and affordable approaches. For integrated CBPHC to be effective at the community level outside of health facilities, CHWs need to have good linkages to the local health facility to which patients with severe illness, injuries and uncommon or more severe illnesses can be referred and where mothers can give birth. Services such as immunizations that require outreach from health facilities also need to be provided at the community level in order to make essential services readily available. Our review includes a number of community–based PHC programs that are presented in **Table 9**.

Table 8. Studies of the effectiveness of Community–Integrated Management of Childhood Illnesses (C–IMCI) and Integrated Community Case Management (iCCM)

Intervention	Type of outcome	Population size of study area	Specific outcome	Effect compared to control	Statistical significance	Reference number*
Randomized controlled trials:						
CHWs trained as part of the family and community activities associated with IMCI, as well as health system strengthening	Mortality; change in nutritional status	The catchment areas of 10 health facilities (175 000 persons)	All–cause mortality 0 to <5 y; prevalence of exclusive breast feeding 0 to <6 mo	Decreased by 13.4%; Increased by 10.1%	0.01; 0.05	[S182]
Non–randomized controlled trials:						
Linkage of CHWs with local health facilities and provision of training to CHWs	Coverage; change in nutritional status	Children 0 to <2 y in a population of 160 000	Percentage of children 12–23 mo fully immunized; percentage of children receiving at least five meals per day	Increased by 21%; increased by 32%	0.05; 0.05	[S183]
Awareness seminars conducted during the first year for leaders of all villages followed 1 y later by similar seminars for extension workers and teachers	Coverage; change in nutritional status	Women of child–bearing age and their children in villages with a total population of 18 000	Percentage of children with full immunization coverage; percentage of children with severe undernutrition	Increased by 50%; decreased by 27%	0.001; 0.05	[S184]
CHWs trained in iCCM	Mortality	Children <5 y in villages with a total population of 14 000	Under–5 mortality	Decreased by 38%	0.003	[S185]
On–site monthly supervision on C–IMCI by trained supervisors of Health Extension Workers (HEWs)	Quality of care	500 HEWs assessed	Quality of case management over two years (percentage of cases that were correctly classified, treated, and followed–up within two days of initiating treatment)	Increased by 200%	0.04	[S186]
C–IMCI with 2 HEWs working at a community health post	Quality of care	87 HEWS	Correct prescription of anti–malarial medications in comparison to HEWs working in a vertical malaria control program	Increased by 10%	0.05	[S187]
Drug sellers trained in iCCM protocols	Quality of care	Sick children who made 7667 visits to 44 trained drug sellers	Correct treatment of common illnesses	Increased by 27%	0.001	[S188]
Peer support groups among CHWs trained in iCCM	Coverage	1575 children in 6 districts	Number of sick children treated for ARI, malaria, and diarrhea (compared to CHWs trained in iCCM without peer support groups)	Increased by 167%	0.001	[S189]
CHWs trained in iCCM	Coverage	306 190 children 6 mo to <5 y	Number of sick children treated for ARI, malaria, diarrhea	Increased by 23%	0.05	[S190]
CHWs trained in iCCM	Coverage	38 009 children <5 y	Percentage of children sleeping under ITNS	Increased by 33%	0.01	[S191]

ARI – acute respiratory infection, HEW – health extension workers, ITN – insecticide–treated bed nets, mo – month(s), y – year(s)

*See Appendix S2 in **Online Supplementary Document**.

Table 9 demonstrates that primary health care with strong community–based components can decrease under–5 mortality. Promotion of community involvement and training/deployment of CHWs is also shown to be a recurring element of these successful programs. Assessments S196–198 are three studies from the Navrongo experiment in Ghana. In the Navrongo experiment in Ghana, there were four groups compared: (1) community health nurses alone–called Community Health Officers, (2) community volunteers and community mobilization without community health nurses; (3) both community health nurses and community volunteers with community mobilization, and (4) a control group. The group that only had community volunteers did not reduce child mortality but did significantly improve child nutrition [S196]. The community–based nurses provided curative care and were effective in decreasing child mortality but did not improve child nutrition or contraceptive coverage [S197]. The best results were achieved when nurses worked with community volunteers and mobilized community members improving child mortality, child nutrition and contraceptive use, together with a 15% improvement in contraceptive coverage [S198].

The census–based, impact–oriented (CBIO) methodology includes mapping and community registering to ensure that all beneficiaries are documented and included in the project information system so that they are included in all community–based PHC programs [S200, S201]. The CBIO approach was pio-

Table 9. Primary health care programs that have strong community–based components

Intervention	Type of outcome	Population size of study area	Specific outcome	Effect compared to control	Statistical significance	Reference number*
Randomized controlled assessments:						
PHC with full range of child health services provided by CHWs plus outreach services.	Change in nutritional status	788 children 6–23 mo	Height–for–age Z score, Weight–for–age Z score	Increased by 24%, increased by 14%	0.018, 0.05	[S196]
PHC nurses posted in communities without CHWs	Mortality	2000 children <5 y	Under–5 mortality	Decreased by 54%	0.05	[S197]
PHC promoting community involvement with volunteer CHWs and well–trained Community Health Officers	Mortality	51407 children <5 y	Mortality of children exposed to intervention for more than 2 y	Decreased by 60%	0.001	[S198]
PHC with full range of child health services provided by CHWs plus outreach services	Mortality	6663 children 0–35 mo, 14551 women	All–cause mortality in children 6–35 mo. Pneumonia– specific mortality in children 6–35 mo	Decreased by 32%. Decreased by 53%.	0.001	[S199]
Non–randomized controlled assessments:						
Census–based PHC with frequent visits by CHWs to all households, distribution of vitamin A, provision of growth monitoring, education, immunizations, and transport assistance when referral needed	Mortality	15406 (total population of intervention area)	All–cause under–5 mortality	Decreased by 52%	0.001	[S200]
Peer education, referral, and promotion of community involvement in planning, implementing, and evaluating services provided by volunteer CHWs	Mortality	36000 children <5 y	All–cause under–5 mortality	Decreased by 58%	0.0001	[S201]
PHC with outreach, health education, supplemental feeding, immunizations, curative treatment, TB control, support of TBAs	Mortality	2700 children aged 0–6 y	All–cause under–5 mortality; stunting	Decreased by 67%; reduced by 28% in children 48–59m	0.0001, 0.001	[S202], [S203]
PHC provided at a health center with community outreach by trained health assistants	Mortality	887 persons in health center catchment area	Crude mortality of all age groups over a time period of 10 y until 1951	Decreased by 24%	0.001	[S204]

CHW – community health worker, mo – month(s), PHC – primary health care, TBA – traditional birth attendant, y – year(s)
*Appendix S2 in **Online Supplementary Document**.

neered in Haiti in the 1970s. Assessment by retrospective maternal birth histories and household anthropometric surveys demonstrated a 68% reduction in under–5 mortality and reduced prevalence of stunting compared to national rural indicators [S202, S203].

The last assessment in **Table 9** is the earliest one in our database and was reported in 1951 [S204]. It was carried out at a time when there had not yet been many experiences with CHWs and when CHWs were used only for health promotion and referral for provision of health services at a health center.

One important study in our database that does not lend itself to incorporation into **Table 9** is the Narangwal Project, which pioneered many elements of CBPHC [S205]. It operated from 1967 to 1973 in the rural Punjab of Northern India. The nutrition and health–care aspects of this study are of direct relevance to CBPHC and child health. There were four cells in the nutrition aspect of this non–randomized controlled study: (A) a nutrition–only cell, (B) a health–care–only cell, (C) a combined nutrition–and–health–care cell, and (D) a control cell (in which routine government services without outreach were provided). Promotion of community participation was a key aspect of the design of this study. Each cell contained approximately 200–300 children. Child nutrition services included growth monitoring and promotion as well as food supplementation twice daily. The child health care services included infectious disease surveillance and early treatment, immunizations, and education concerning disease prevention. In the nutrition study, mortality rates were significantly reduced during the perinatal, neonatal, post–neonatal, and 12–23 month age groups in both the nutrition cell as well as in the nutrition + health care cell compared to the control cell. In addition, the weight–for–age and height–for–age of children beyond 17 months of age were significantly greater in the nutrition cell and in the nutrition + health care cell compared to control cell [S205].

Key CBPHC aspects of this project were that Family Health Workers provided treatment in the home for dehydration from diarrhea and for childhood pneumonia. The children 0–3 years of age with pneumonia who were treated with penicillin had a 42% reduced risk of overall mortality [S206]. Other key findings based on a qualitative review of data were that: one–on–one education of mothers was essential for im-

proving practices related to breastfeeding, infant feeding, rehydration and feeding of sick infants and also for overcoming traditional beliefs about not feeding a child with diarrhea; weekly home visits were necessary in order to achieve a reduction in infant mortality; delegation of services as far to the periphery as possible improved coverage and effectiveness; rehabilitation of malnourished children through special feeding programs was best accomplished at home or near the home; having a curative health care service was an essential element of building trust, and developing a quality health care program required active community participation and building trust with the community [S207].

Several other assessments included in our database are of particular note since they document the evidence of the long–term benefits of CBPHC projects on child health. These projects are:

- The ICDDR,B MCH–FP Program in Matlab, Bangladesh (a maternal/child health and family planning research field site for the International Centre for Diarrheal Disease Research, Bangladesh/Centre for Health, Population and Nutrition);
- The Hôpital Albert Schweitzer in Deschapelles, Haiti;
- The Jamkhed Comprehensive Health Project in Jamkhed, India; and,
- SEARCH (Society for Education, Action and Research in Community Health) in Gadchiroli, India.

These projects are discussed in detail elsewhere in this supplement [15].

DISCUSSION

This review provides strong evidence that overall the major causes of child mortality in developing countries can be addressed at the community level outside of health facilities by working with communities and community–level workers. For all categories of interventions, we have presented findings from randomized and non–randomized controlled trials in our database that have consistently produced statistically significant and operationally important effects. In many cases the outcomes observed have been changes in the most objective and meaningful indicator: mortality.

Some assessments, mostly unpublished child survival project evaluations, relied on before/after study designs without a comparison group, measuring changes in population coverage of key child survival interventions. In virtually all cases, the changes in coverage over a 4–5 year period were quite pronounced, particularly in comparison to much smaller changes in coverage in the regional or national population, as a review of a set of these projects has demonstrated [16]. They have generally produced statistically significant and operationally important results. Other less rigorous assessments of the effectiveness of CBPHC in improving child health were not included in this article due to space limitations, but they also provide evidence supporting our major findings presented here.

Our findings regarding the effectiveness of specific community–based interventions for improving child health are similar to those reported in other reviews [4,17]. The provision of iron to children in malaria–endemic areas, whether through community–based approaches or otherwise, may have harmful effects so it not recommended at this time. However, this is the only evidence we have identified in which implementation of CBPHC intervention led to a less than favorable effect. However, it is important to note that this finding pertains to the biomedical interaction of iron on children exposed to malaria rather than on the effectiveness of CBPHC as a strategy for improving child health. At the community level the total number of interventions being implemented – even in a comprehensive primary health care approach – may be spread amongst several CHWs working in a team each of whom may do only one or two interventions. Consequently, evidence about the effectiveness of one or two interventions implemented by individuals, usually CHWs, is consistent with "community–based primary health care."

We have not addressed here three important questions: (1) who are the community–level workers who implemented the interventions, (2) what particular resources do they need in order to deliver the interventions, and (3) what are the conditions that would need to be met in order to scale up these interventions under routine conditions. Answering these questions is beyond the scope of this paper, and few assessments really address these questions, unfortunately. The degree to which the assessments included here represent efficacy studies (that is, project implementation under ideal field conditions) as opposed to effectiveness studies (implementation under routine field conditions) cannot be adequately explored here. However, it is clear that appropriately trained, supervised and supported CHWs along with engaged communities are needed to achieve effectiveness, and these conditions appear to have been met in the projects included in our review.

This review demonstrates that four major strategies for delivering community–based primary health care interventions are effective and commonly used in projects that have improved child health. These strategies are (1) house–to–house visitation by CHWs; (2) community case management of childhood illness, (3) use of participatory women's groups; and (4) outreach services provided in the community by mobile teams based at peripheral health centers. CHWs visit households to educate child caregivers about prevention and manage common illnesses. Through following well–developed protocols, CHWs link community members to their nearest health facility for management of serious illness or follow up. These strategies are discussed in detail elsewhere in this series from the perspective of CBPHC strategies for improving maternal, neonatal as well as child health [18].

Many assessments included in our review support the importance of community engagement. A systematic review of child survival programs has found that programs working collaboratively with the community can lead to cost–effective transformation and lasting behavior change that produces improved health outcomes [19]. As a result of such engagements, the knowledge that community members have about what works locally is more likely to be shared with health program staff because they have a shared responsibility for program planning, implementation and evaluation. Without being a stakeholder, community members may see programs as imposed from the outside and not responsive to their needs. Without community engagement, programs may not produce the best outcomes that might otherwise be achieved through strong community engagement.

While we have made every effort to include all relevant studies that meet our criteria, some important studies have escaped our screening process. One such study concerns the use of pre–referral rectal artesunate [20]. In a randomized controlled trial in Bangladesh, Ghana and Tanzania, patients aged 6 to 72 months with suspected severe malaria who could not be treated orally were allocated randomly to receive a single rectal dose of artesunate (n = 8954) or placebo (n = 8872) before referral to a clinic where antimalarial injections could be given. In patients who had not reached a clinic within 6 hours, half of whom had not reached a clinic within 15 hours, pre–referral artesunate significantly reduced death or permanent disability by half (1.9% in the intervention group compared to 3.8% in the control group).

Several studies included in our review confirmed the effectiveness of Integrated Community Case Management (iCCM) (**Table 8**). However, several recent evaluations published since the end–point of publications selected for our review (31 December 2015) have found that iCCM, when implemented at scale, has not expanded coverage of key child survival interventions or reduced under–5 mortality, partly because of shortcomings related to training, supervision and drug stock outs [21] and low levels of care seeking [22,23]. Perhaps CHWs trained in iCCM are not able to make frequent home visits and therefore unable to give sufficient attention to educating mothers about warning signs for which they should seek care or to earn their confidence. Their broader job responsibilities beyond iCCM, including providing curative care for adults and family planning for women, as well as the large size of their catchment areas (sometimes more than 2 hours away from their health post) make frequent home visits virtually impossible.

As the Narangwal project demonstrated four decades ago, the provision of some curative care builds community trust in the CHWs providing it. It also facilitates referral to local health facilities as needed. However this trust is difficult to develop if the CHWs are not in regular contact with all households and if community members are not convinced that the CHWs are well trained and competent. One particularly important recent example of the effectiveness achieved by meeting these conditions occurred in Yirimadjo, Mali [S93]. The intervention included CHW active case finding, user fee removal, infrastructure development, community mobilization and prevention programming. After three years of the intervention, the hazard of under–5 mortality in the intervention area was one tenth that of baseline (HR 0.10 $P < 0.0001$), the prevalence of febrile illness of children younger than 5 years of age was significantly lower, from 38% at baseline to 23% at endline ($P = 0.0009$) and the percentage of children starting an effective antimalarial with 24 hours of symptom onset was nearly twice that reported at baseline ($P = 0.0195$).

The assessments from the Navrongo project in Ghana [S196–198] demonstrate that the best results were achieved when the community nurses worked in conjunction with trained community volunteers and community mobilization. The particular processes of community mobilization focused on working through the traditional community structure and engaging persons with a leadership role within the community. While the community–based nurses did have some impact on child mortality through their provision of prompt curative treatment, they did not have significant impact on contraceptive use or on child nutrition that require a high level of trust between community members and providers that can be achieved by community participation and door–to–door provision of support and health education [24]. A more

recent evaluation of the extension of this program across Ghana indicates that an ongoing systematic approach with regular planning, monitoring and supervision of health workers, and close collaboration with community leaders needs to be followed to produce lasting results at scale [25].

For CBPHC to be most effective it must reach all households, including the poorest families, all mothers, those households far away, and those who are members of religious or ethnic minorities. In our review, the census–based, impact–oriented (CBIO) approach and Care Groups have demonstrated the importance of registering and visiting frequently all households with mothers and children, as more recent evidence has also demonstrated [26,27] . The Care Group approach has achieved excellent results at low cost [14] and is currently being implemented in many priority countries [13].

The following essential interventions for child health that can be provided at the level of the community and/or health post by CHWs have been identified [1]:

- Promote breastfeeding (including exclusive breastfeeding during the first six months of life) and appropriate complementary feeding beginning at 6 months of age
- Provide vitamin A and zinc supplementation
- Provide co–trimoxazole for HIV–positive children
- Educate families on safe disposal of children's stools and hand washing
- Distribute and promote use of ITNs or IRs or both
- Detect and refer children with severe acute malnutrition
- Prevent, diagnose and treat pneumonia of pneumonia, malaria and diarrheal diseases with early referral of those children with danger signs of serious disease.

The strong and consistent evidence that we have presented in this paper clearly demonstrates that all these Essential Interventions can be delivered at the community level with favorable population–level results for children.

The findings from this review also provide strong evidence that the four key strategies of delivering community–based interventions are effective approaches for achieving implementation effectiveness through CBPHC. These strategies are: (1) house–to–house visitation by CHWs; (2) community case management of childhood illness, (3) use of participatory women's groups; and (4) outreach services provided in the community by mobile teams based at health centers. We have also presented evidence that community participation and mobilization make a strong contribution to intervention effectiveness.

Study limitations

Some of the studies included in our review lacked sufficient information about the assessment methodology, about the role of community members and other implementation strategies, as well as about the outcomes themselves. This sometimes made it difficult to assess the strength of the evidence and to draw firm conclusions. We worked to mitigate this limitation by, in some cases, following up with the authors of these assessments.

Due to space limitations not all 489 assessments of the effectiveness of CBPHC in improving child health could be cited in this analysis. However, the findings of the assessments not specifically cited here are consistent with and supportive of those that were cited.

As is well–known, project failures and serious challenges encountered in program implementation are rarely described in open–access documents or in the scientific literature. This means that a serious publication bias is present and should be recognized. Nonetheless, publication bias does not negate the value of the numerous assessments that have been included in our review that demonstrate effectiveness of CBPHC in improving child health. The consistency of findings across many assessments in relationship to most interventions is such that we are convinced that the general findings with respect to each specific intervention are valid.

We acknowledge that there may be some assessments that qualified for our review that were not picked up by our screening procedures. However, we do not think that the inclusion of any articles we might have missed would alter the overall findings from our review. In addition, we are aware that there are important findings in papers published after December 2015 that did not fit the timeline of our review, but we have highlighted them in the discussion.

Our review has identified several areas of further study that are needed to address gaps in current knowledge to improve the implementation of child health programs at the community level. These areas are:

- Effectiveness studies of the implementation of community based interventions at scale in large populations in routine settings for 5 or more years;
- Effectiveness studies on how best to involve communities in the monitoring, implementation and evaluation of these settings.

As can be readily seen from the tables in this paper there is a clear lack of assessments of studies of interventions in large populations at scale. In the final paper of this series [28] the Expert Panel highlights the need for more evidence from programs delivered at scale. Similarly, while we have provided evidence that many interventions can be implemented successfully at the community level, the actual results produced in the field depend on how well community members "own" and therefore use the interventions provided in a sustainable manner. How to best do this needs further investigation.

Given the heterogeneity of (1) the types of interventions implemented, (2) the manner in which they were implemented, and (3) the outcome measures used to assess outcomes, it is not possible to make any definitive statements about the strength of the evidence or the magnitude of effect for any specific intervention or any specific approach to implementation, or how any given intervention or implementation approach compares with another in terms of effectiveness. Moreover, addressing the important issue of how to most effectively integrate interventions into a balanced package of services so that the demands for implementation of one intervention do not override the requirements for implementation of another intervention is beyond the scope of this paper, as is the important issue of how to strengthen health systems more broadly to better support the implementation of effective CBPHC interventions for improving child health.

Nonetheless, consistent with the purpose of our overall review of the effectiveness of CBPHC in improving MNCH, our overall findings strongly support the conclusion that (1) CBPHC can in fact be effectively implemented at the community level to improve child health and (2) robust community–based delivery systems are needed in order for the evidence–based interventions currently known and those that will be developed can reach their full potential.

CONCLUSIONS

We have presented the evidence of effectiveness of a broad range of community–based interventions for improving the health of children 1–59 months of age. Health systems that are capable of achieving universal coverage of these interventions in high–mortality settings are clearly needed. Achieving this capability will require strong support for the health system as well as a strong commitment to a well–trained and well–supported CHW cadre in sufficient numbers. Understanding the conditions that need to be met in order for these interventions to be effective at scale in routine settings in priority countries and ensuring that these conditions are met will be the major challenge in the decade to come.

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REFERENCES

1 Black RE, Levin C, Walker N, Chou D, Liu L, Temmerman M, et al. Reproductive, maternal, newborn, and child health: key messages from Disease Control Priorities 3rd Edition. Lancet. 2016;388:2811-24.

2 Liu L, Johnson HL, Cousens S, Perin J, Scott S, Lawn JE, et al. Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000. Lancet. 2012;379:2151-61. Medline:22579125 doi:10.1016/S0140-6736(12)60560-1

3 Black RE, Victora CG, Walker SP, Bhutta ZA, Christian P, de Onis M, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. Lancet. 2013;382:427-51. Medline:23746772 doi:10.1016/S0140-6736(13)60937-X

4 Lassi ZS, Kumar R, Bhutta ZA. Community-based care to improve maternal, newborn, and child health. 2016. In: Disease Control Priorities: Reproductive, Maternal, Newborn, and Child Health, Third Edition. Washington, DC: World Bank, Available: https://openknowledge.worldbank.org/bitstream/handle/10986/23833/9781464803482.pdf?sequence=3&isAllowed=y. Accessed: 20 March 2017.

5 Perry H, Rassekh B, Gupta S, Wilhelm J, Freeman P. A comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 1. rationale, methods and database description. J Glob Health. 2017;07:010901.

6 Jennings M, Pradhan S, Schleiff M, Sacks E, Freeman P, Gupta S, et al. A comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 2. maternal health findings. J Glob Health. 2017;7:010902.

7 Sacks E, Freeman P, Sakyi K, Jennings M, Rassekh B, Gupta S, et al. A comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 3. neonatal health findings. J Glob Health. 2017;7:010903.

8 WHO. UNICEF. ending preventable child deaths from pneumonia and diarrhoea by 2025. The integrated Global Action Plan for Pneumonia and Diarrhoea (GAPPD). 2013. Available: http://www.unicef.org/immunization/files/GAPPD.pdf. Accessed: 20 March 2017.

9 Jones G, Steketee RW, Black RE, Bhutta ZA, Morris SS. How many child deaths can we prevent this year? Lancet. 2003;362:65-71. Medline:12853204 doi:10.1016/S0140-6736(03)13811-1

10 Pelletier DL, Frongillo EA Jr, Schroeder DG, Habicht JP. The effects of malnutrition on child mortality in developing countries. Bull World Health Organ. 1995;73:443-8. Medline:7554015

11 Caulfield LE, de Onis M, Blossner M, Black RE. Undernutrition as an underlying cause of child deaths associated with diarrhea, pneumonia, malaria, and measles. Am J Clin Nutr. 2004;80:193-8. Medline:15213048

12 Bosch-Capblanch X, Marceau C. Training, supervision and quality of care in selected integrated community case management (iCCM) programmes: a scoping review of programmatic evidence. J Glob Health. 2014;4:020403. Medline:25520793 doi:10.7189/jogh.04.020403

13 Perry H, Morrow M, Borger S, Weiss J, DeCoster M, Davis T, et al. Care Groups I: an innovative community-based strategy for improving maternal, neonatal, and child health in resource-constrained settings. Glob Health Sci Pract. 2015;3:358-69. Medline:26374798 doi:10.9745/GHSP-D-15-00051

14 Perry H, Morrow M, Davis T, Borger S, Weiss J, DeCoster M, et al. Care Groups II: a summary of the maternal, neonatal and child health outcomes achieved in high-mortality, resource-constrained settings. Glob Health Sci Pract. 2015;3:370-81. Medline:26374799 doi:10.9745/GHSP-D-15-00052

15 Perry H, Rassekh B, Gupta S, Freeman P. A comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 7. programs with evidence of long-term impact on mortality in children younger than five years of age. J Glob Health. 2017;7:010907.

16 Ricca J, Kureshy N, Leban K, Prosnitz D, Ryan L. Community-based intervention packages facilitated by NGOs demonstrate plausible evidence for child mortality impact. Health Policy Plan. 2014;29:204-16. Medline:23434515 doi:10.1093/heapol/czt005

17 Bhutta ZA, Das JK, Rizvi A, Gaffey MF, Walker N, Horton S, et al. Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost? Lancet. 2013;382:452-77. Medline:23746776 doi:10.1016/S0140-6736(13)60996-4

18 Perry H, Rassekh B, Gupta S, Freeman P. A comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 6. strategies used by effective projects. J Glob Health. 2017;7:010906.

19 Farnsworth SK, Bose K, Fajobi O, Souza PP, Peniston A, Davidson LL, et al. Community engagement to enhance child survival and early development in low- and middle-income countries: an evidence review. J Health Commun. 2014;19 Suppl 1:67-88. Medline:25207448 doi:10.1080/10810730.2014.941519

20 Gomes MF, Faiz MA, Gyapong JO, Warsame M, Agbenyega T, Babiker A, et al. Pre-referral rectal artesunate to prevent death and disability in severe malaria: a placebo-controlled trial. Lancet. 2009;373:557-66. Medline:19059639 doi:10.1016/S0140-6736(08)61734-1

21 Munos M, Guiella G, Roberton T, Maiga A, Tiendrebeogo A, Tam Y, et al. Independent evaluation of the rapid scale-up program to reduce under-five mortality in Burkina Faso. Am J Trop Med Hyg. 2016;94:584-95. Medline:26787147 doi:10.4269/ajtmh.15-0585

22 Amouzou A, Hazel E, Shaw B, Miller NP, Tafesse M, Mekonnen Y, et al. Effects of the integrated community case management of childhood illness strategy on child mortality in Ethiopia: A cluster randomized trial. Am J Trop Med Hyg. 2016;94:596-604. Medline:26787148 doi:10.4269/ajtmh.15-0586

REFERENCES

23 Shaw B, Amouzou A, Miller NP, Tsui AO, Bryce J, Tafesse M, et al. Determinants of Utilization of Health Extension Workers in the Context of Scale-Up of Integrated Community Case Management of Childhood Illnesses in Ethiopia. Am J Trop Med Hyg. 2015;93:636-47. Medline:26195461 doi:10.4269/ajtmh.14-0660

24 Phillips JF, Bawah AA, Binka FN. Accelerating reproductive and child health programme impact with community-based services: the Navrongo experiment in Ghana. Bull World Health Organ. 2006;84:949-55. Medline:17242830 doi:10.2471/BLT.06.030064

25 Nyonator FK, Jones TC, Miller RA, Phillips JF, Awoonor-Williams JK. Guiding the Ghana community-based health planning and services approach to scaling up with qualitative systems appraisal. Int Q Community Health Educ. 2004-2005;23:189-213. doi:10.2190/NGM3-FYDT-5827-ML1P

26 Marcil L, Afsana K, Perry HB. First steps in initiating an effective maternal, neonatal, and child health program in urban slums: the BRAC Manoshi Project's experience with community engagement, social mapping, and census taking in Bangladesh. J Urban Health. 2016;93:6-18. Medline:26830423 doi:10.1007/s11524-016-0026-0

27 Perry H, Davis T. The effectiveness of the census-based, impact-oriented (CBIO) approach in addressing global health goals. In: E. B, editor. Aid Effectiveness in Global Health. New York: Springer; 2015.

28 Black RE, Taylor CE, Arole S, Bang A, Bhutta ZA, Chowdhury AMR, et al. A comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 8. conclusions and recommendations of an Expert Panel. J Glob Health. 2017;7:010908.

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Comprehensive review of the evidence regarding the effectiveness of community–based primary health care in improving maternal, neonatal and child health: 5. equity effects for neonates and children

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Background The degree to which investments in health programs improve the health of the most disadvantaged segments of the population—where utilization of health services and health status is often the worst—is a growing concern throughout the world. Therefore, questions about the degree to which community–based primary health care (CBPHC) can or actually does improve utilization of health services and the health status of the most disadvantaged children in a population is an important one.

Methods Using a database containing information about the assessment of 548 interventions, projects or programs (referred to collectively as projects) that used CBPHC to improve child health, we extracted evidence related to equity from a sub–set of 42 projects, identified through a multi–step process, that included an equity analysis. We organized our findings conceptually around a logical framework matrix.

Results Our analysis indicates that these CBPHC projects, all of which implemented child health interventions, achieved equitable effects. The vast majority (87%) of the 82 equity measurements carried out and reported for these 42 projects demonstrated "pro–equitable" or "equitable" effects, meaning that the project's equity indicator(s) improved to the same degree or more in the disadvantaged segments of the project population as in the more advantaged segments. Most (78%) of the all the measured equity effects were "pro–equitable," meaning that the equity criterion improved more in the most disadvantaged segment of the project population than in the other segments of the population.

Conclusions Based on the observation that CBPHC projects commonly provide services that are readily accessible to the entire project population and that even often reach down to all households, such projects are inherently likely to be more equitable than projects that strengthen services only at facilities, where utilization diminishes greatly with one's distance away. The decentralization of services and attention to and tracking of metrics across all phases of project implementation with attention to the underserved, as can be done in CBPHC projects, are important for reducing inequities in countries with a high burden of child mortality. Strengthening CBPHC is a necessary strategy for reducing inequities in child health and for achieving universal coverage of essential services for children.

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Martin Luther King, Jr., in a speech in 1966 to the Medical Committee for Human Rights, proclaimed, "*Of all the forms of inequality, injustice in health care is the most shocking and inhumane*" [1]. Between countries and within countries, inequalities in health status are by and large considered inequitable because they can be greatly reduced or even eliminated through stronger health programs. In spite of marked improvements in health programming and health status around the world, inequities are not diminishing as much as many countries and stakeholders had hoped [2–4]. Particularly since the 1990s, measuring and working to reduce inequities — with a goal ultimately to reach zero — has been on the global health agenda from global and national policy–makers to major donors [3–6].

Issues of health inequities for maternal, neonatal and child health (MNCH) in low– and middle–income countries (LMICs) are being increasingly studied. Some progress is being made in a number of areas such as the use of insecticide–treated net (ITN) usage to prevent malaria, exclusive breastfeeding, and immunization coverage [7]. Further, approaches for reaching underserved populations are receiving increasing attention in order to achieve the Millennium Development Goals (MDGs) [4] and the newly established Sustainable Development Goals (SDGs) [8]. At the global level, a recent declaration [9] brought together national public health associations from around the world to focus and mobilize action for achieving health equity by building evidence, addressing the social determinants of health (SDH), and incorporating equity components into health policies. Nonetheless, a great deal of learning and work remains to be done in order to accelerate reductions in health inequities.

Recent evidence from tracking of the "Countdown to 2015" [7–12], when the MDGs were supposed to be achieved, shows that population coverage of key interventions provided by health services is improving for the poorest quintiles of national populations at a rate faster than that for the wealthiest quintiles. However, the poorest quintiles are still facing markedly lower levels of coverage than the wealthier quintiles in most Countdown countries (the 74 countries with 97% of the world's child and maternal deaths, ie, the greatest burden of maternal, neonatal and child mortality). Even though some measures of health inequities are slowly improving, substantial challenges remain for how to accelerate this progress [3,4]. The gaps are wider for interventions that require access to fixed health facilities or repeat contacts with a health provider (such as a skilled birth attendant) than for interventions that can be delivered through outreach strategies at the community level [5]. The countries that have made rapid progress in coverage are those that effectively reached the poorest families [5]. This is despite starting with great inequities. For example, in Cambodia and Sierra Leone in 2000 the richest had much higher coverage than the rest, but by 2014 this difference had disappeared [13].

The terminology around inequities, inequalities, and disparities has been the topic of debate over the past decades [14]. We will use the following interpretations of the terms in the context of this article. *Disparities* and *inequalities* (often used interchangeably) refer to differences among socially or geographically defined groups in health service utilization, in risk factors for unfavorable health outcomes, in levels of morbidity or mortality (collectively referred to here as health status) – essentially encompassing the entirety of epidemiological inquiry [14]. *Inequity*, however, "does not refer generically to all differences in health, but focuses specifically on the sub–set of differences that are 'avoidable, unfair, and unjust" [14]. In practice, studies of inequities in health often focus on the degree to which marginalized and disadvantaged groups within geographically defined populations have less access to health care resources and have lower utilization of health care services.

Such differences stem from characteristics such as educational level, income (or wealth), race, child's gender, geographic location, religion, or other characteristics of a social group that persistently produce social barriers that can lead to health outcomes that are different from those of other social groups. Beyond the semantics, Braveman argues that how we define and use these terms has important and relevant implications for policy and practice, and these definitions can determine the measures used to determine progress and even the flow of funding for different interventions [14]. Alternately, Taylor suggested a definition of equity as the, "distribution of benefits according to demonstrated need [health status] rather than on the basis of political or socioeconomic privilege" [15]. He focused on equity of the health status of populations rather than more proximal indicators of health system inputs or health service utilization.

From a public health perspective, it is important to examine the equity of both health program implementation and health outcomes among different socially and geographically defined sub–populations. Overall improvements in the health of a population can occur without every sub–group benefiting equally [7,16,17].

The equity effects of MNCH programs have undergone perhaps the greatest scrutiny of any global health program. One of the recent drivers for this scrutiny was the challenge of meeting the MDGs by 2015 and

accelerating progress in countries that were lagging behind [11,12,18]. Analysts observed that, within many countries, inequities in child mortality were widening in spite of overall downward trends in child mortality [19].

Analyses have been conducted using Demographic and Health Survey (DHS) and Multiple Indicator Survey (MICS) data from MDG Countdown Countries regarding the population coverage of key maternal and child health interventions by income quintiles to assess equity in coverage [4,5]. Results showed trends toward increased equity in coverage of key interventions. Some of the most equitably implemented interventions are those that can fairly easily be implemented within communities, such as ITN utilization, promotion of exclusive breastfeeding (EBF), and community–based provision of immunizations [7,10,20,21]. At the same time, widening inequities were observed among different population sub–groups for interventions that require facility–based, higher–level personnel such as skilled birth attendants and treatment of serious childhood illness [22]. These interventions often require a more developed health system including education and support of skilled personnel, more advanced equipment, referral processes, and other support structures in order to be effective, and thus tend to be less evenly distributed among population groups [7,10].

While equity issues are often considered from a national or large–population perspective, they may exist at the local level as well. In one long–standing comprehensive health program in Haiti serving 148 000 people with a strong community–based service delivery system, the utilization of health facilities, the population coverage of key interventions, and the health outcomes of sub–groups of the program area differed markedly among those living in the more isolated mountain communities compared to those is nearer valley communities. This reality persisted despite great efforts being made to extend both primary health care services and access to CHWs equally throughout the program area [23].

This article makes two contributions to the equity literature. First, it consolidates for the first time the evidence regarding the equity effects of CBPHC programs on child health and organizes them around a logical framework. Second, this article reviews the various dimensions of equity that child health programs need to consider, including wealth (or household assets), maternal education, child's sex, geographic location, and gender of the child's caregiver and identifies dimensions where limited analysis has been conducted.

METHODS

Data sources

We used a recently assembled database containing assessments of 548 studies, projects or programs (referred to collectively as projects) that used CBPHC (defined in the initial paper in this series [24]) to improve neonatal or child health (henceforth referred to as child health) and to document these improvements. In brief, CBPHC was considered to be one or more interventions carried out in the community outside of a health facility. The additional presence of one or more facility–based interventions did not disqualify the project from inclusion.

The database and its assembly have been described elsewhere in this series [10]. In short, peer–reviewed documents, reports and books assessing the impact of one or more CBPHC interventions on child health (coverage of a key child survival indicator, nutritional status, serious morbidity, or mortality) in LMIC settings, among children in a geographically defined population, were selected. Two independent data extraction reviews were carried out and followed by an independent consolidated summative review. Data from the latter review were transferred to electronic database.

From this database, we identified a sub–set of 42 projects that had carried out an equity analysis as part of their assessment using the process described in the following section.

Article review and inclusion process

Using the PRISMA guidelines for systematic reviews on health equity [25,26], we identified a sub–set of 138 articles in which equity was mentioned in one or more of the following fields in the CBPHC project database: 1) the title of the article, 2) the documentation of the process of the intervention, 3) part of the data analysis strategy, or 4) in the notes provided by the reviewers of the assessment for inclusion in the

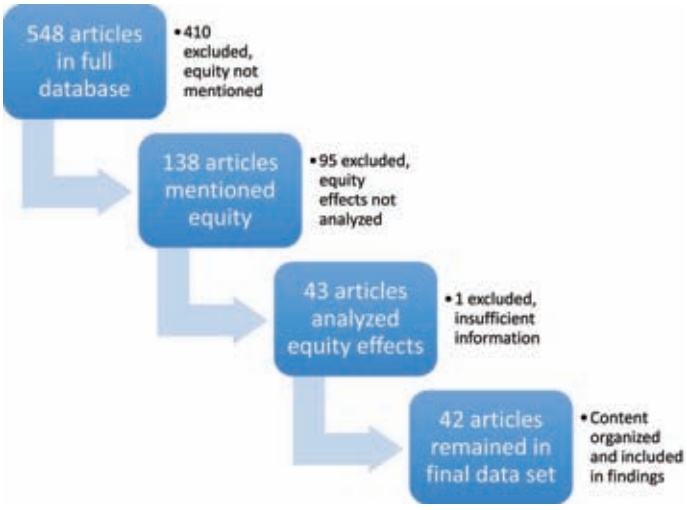


Figure 1. Overview of sequence of article review and inclusion/exclusion criteria.

systematic review. We carefully reviewed this sub–set of equity–relevant assessments and excluded assessments in which equity was not actually analyzed across population subgroups. After this focusing phase, we were left with 43 projects to examine further.

Two of the authors (MS and RK) separately reviewed each of these 43 projects and extracted additional data on how equity was defined in each assessment, what data sources were utilized for assessment of equity effects, and what the outcome on equity actually was. The metrics from each project being assessed were stratified into log–frame categories (input, process, output, outcome, impact). One article was excluded from the analysis because it did not provide sufficient information on how equity was analyzed, leaving 42 articles in the final data set (**Figure 1**). Aside from the availability of adequate information on equity analysis in each article, the quality of the study was not assessed.

Criteria for equity analysis

In order to identify the diverse criteria utilized among the studies to analyze equity, we created open–text responses as we reviewed each assessment, and then categorized them into common themes as we identified commonalities among the identified categories. We summarize the categories below and provide examples for some of the less–common categories. In our literature review, we identified a USAID report [27] on incorporating equity into project designs for MNCH that offered guidance on identifying disadvantaged groups that should be considered in implementing equitable MNCH projects. The USAID report referred to these groups by the acronym PROGRESS (**P**lace of residence, **R**ace, **O**ccupation, **G**ender, **R**eligion, **E**ducation, and **S**ocioeconomic **S**tatus) [28]. This typology provided guidance for the kinds of characteristics to look for and how to organize the findings from the reports we analyzed.

Categorization of equity outcomes

We created three categories of outcomes for the various equity indicators used by the assessments included in our analysis (pro–equitable, equitable, and inequitable, as defined in **Box 1**). We categorized indicators as pro–equitable if findings favored underserved populations and were statistically significant or, if tests of statistical significance were not carried out, the study authors described their results as having practical significance. Indicators with findings that were similar for underserved groups as for the other groups were categorized as equitable. Indicators with findings that showed unfavorable outcomes for underserved populations were categorized as inequitable.

These categories helped us to differentiate between several important equity outcomes –namely when disadvantaged sub–groups were benefitting less, equally, or more than other sub–groups. If disadvantaged

Box 1. Definitions

Pro–equity effect: when inputs, processes, and outcomes for disadvantaged groups improved more than for advantaged groups by the end of project implementation.

Equity effect: when inputs, processes, and outcomes for disadvantaged groups improved to the same degree as advantaged groups by the end of project implementation.

Inequity effect: when inputs, processes and outcomes for disadvantaged groups improve less than for advantaged groups by the end of project implementation.

Dimension of equity: A characteristic — such as household income, level of maternal education, or whether a child lives in an urban or rural areas — that can be used to compare population groups through an equity lens and determine whether different sub–groups of the population receive different levels of services or achieve different outcomes.

Equity indicator: An indicator of child health—such as rates of home visitation for newborns, for example — that was analyzed across a dimension of health equity.

groups were benefitting less, this was an inequitable outcome. When disadvantaged groups were benefitting equally, this was noted as a good sign, though not a fully optimal outcome since disadvantaged groups often need to make additional progress in order to overcome inequities.

Organization of identified metrics for health equity into a logical framework

Barros et al. [19] offer a framework for analysis of health equity from the standpoint of an individual person's experience with an illness, beginning with the socioeconomic context through exposures to disease, vulnerability to succumbing to disease, and the outcomes and consequences of illness. While this approach helped us think through the various ways that equity can influence child health work, we opted to organize the indicators of health equity used by the assessments included in our analysis by utilizing a different framework of analysis from the standpoint of project implementation: beginning with inputs and processes, and then moving to outputs, outcomes, and impacts [29] to track at what point in project implementation equity dimensions were assessed. This made it possible to identify gaps and opportunities from a project planning and implementation perspective. **Figure 2** below provides a graphic representation of the conceptual flow of this log–frame matrix from one phase to another.

We created a matrix for each phase of the logical framework and, for each of the included indicators, tabulated the equity effects of each project. For each cell of the matrix, we described the content of the project and drew conclusions from the available evidence.

Each assessment was further analyzed to determine the criteria used to define equity, the type of data used to assess equity, and the scope of the assessment as well as the types of indicators measured in the assessment. The definition of equity was not pre–determined, and the definitions of equity used in the assessments were categorized after the list of equity indicators used in the projects had been reviewed. This was done to avoid missing any relevant equity indicators that might not have fit into a pre–determined definition of equity.

The type of data used to assess equity was defined as primary or secondary. The term primary data refers to data collected by the project, while the term secondary data refers to data which were gathered by another entity. Secondary data included those obtained from DHS and MICS data sets. Finally, each indicator was further classified as to whether it was referring to a project input, process, output, outcome or impact.

Table 1. Geographical location of reports containing equity analyses

Geographical region	Number of studies
Africa	19
Southeast Asia	14
Americas	8
Western Pacific	1
Total	42

RESULTS

Location of included projects

The assessments included in our analysis were for projects from various regions of the world (**Table 1**). One of the studies included data from 28 African countries, and another had data from four African countries. All other studies focused on one country or a smaller sub–population within that country as shown in **Table 1**.

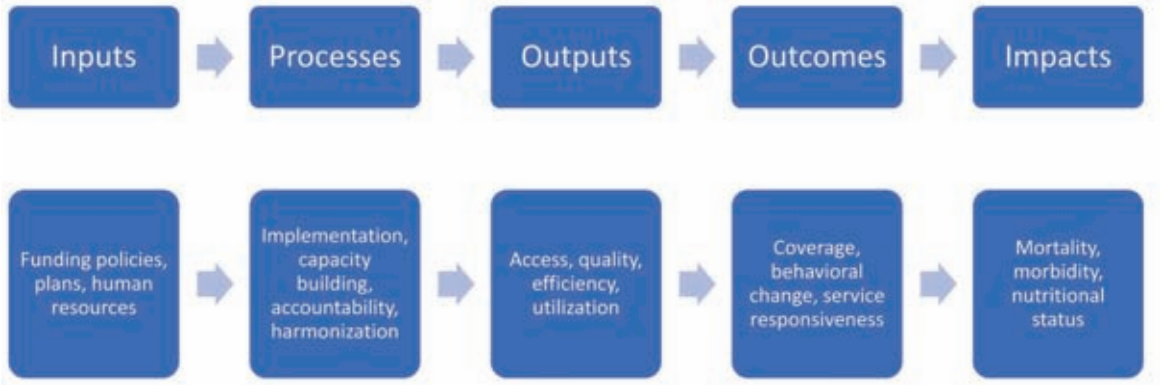


Figure 2. Generalized log frame for health projects.

Kinds of data used in the assessments

The data utilized in 37 of the 42 projects including equity analyses collected specifically by the project within the project's geographic area. However, five analyses exclusively utilized data from DHS and MICS surveys, and two utilized both project–level data collected for assessment of the project and also publicly available national data.

Criteria through which equity effects were assessed

Across the 42 projects included in our analysis, 82 equity indicators — for example coverage of prenatal home visits analyzed across household income categories (Callaghan–Koru, 2013; reference [S15] in **Online Supplementary Document**) — were identified. Equity was measured by comparing changes in health program characteristics or health status over time for more disadvantaged groups with changes in the identical indicators for more advantaged groups. **Table 2** summarizes the criteria by which disadvantaged groups were distinguished from more advantaged groups.

We grouped several equity indicators under a category we refer to as socioeconomic status (SES). These included income categories, maternal education, and household characteristics. By far, the most common indicator for assessing equity was a measure of wealth, often based on household income, household assets, household size, or maternal earnings. Other SES equity indicators included in the analysis were agricultural production by heads of household and specific assets present in the household such as a working toilet, running water, or a refuse collection system. Other SES criteria included the ethnic group of the family, religion, marital status of child's parents, occupation of the parents, and demographic characteristics such as maternal age. These equity indicators aligned well with those identified by the USAID PROGRESS report (shown in the right–hand column of **Table 2**); the only PROGRESS category that was not identified in our analysis was religion [27].

Assessments of equity of inputs

After careful analysis and discussion among co–authors and colleagues, we determined that no projects that we included in our data set explicitly analyzed or reported inputs from an equity perspective. The dearth of input–related efforts in project design, implementation, and evaluation is concerning and is noted as an area where further work is needed.

Assessments of equity of processes

A number of the assessments included in our review measured process indicators through an equity lens, as shown in **Table 3** (references in Tables 3–6, are prefixed with an S and appear in **Online Supplementary Document**). Two–thirds (10/13) of the measurements of equity involving process indicators concerned whether the household had received a home visit from a health worker or had contact with the health system. Eleven out of 13 of the measurements yielded a pro–equitable result, and the remaining two yielded an equitable result. Thus, for the process indicators in the assessments selected for analysis, equity had been achieved in all cases and a pro–equity result is observed in almost all. The findings for

Table 2. Equity indicators used in the assessments included in the analysis

Equity criterion	Number of assessments in which the indicator was used*	Comparable USAID PROGRESS Indicators
Socioeconomic status (SES):		
Household income categories	45	Wealth
Household assets (production, other assets such as savings)	5	Wealth
Maternal education	9	Gender
Social standing (ethnicity, caste, religion, parent marital status)	8	Ethnicity
Parent occupation	1	Wealth
Other:		
Geographic location of residence (urban vs rural)	24	Geography
Child's sex	3	Gender
Nutritional status	4	Wealth
Maternal age	2	Age
Country–level Human Development Index (HDI)	1	Wealth

*The column total is 82 since many of the assessments in our review included more than one equity indicator.

Table 3. Assessments of equity effects of CBPHC projects using process indicators*

Process indicator	Equity criterion	Outcome	Reference
Postnatal home visit	Household income	Equitable	Callaghan–Koru 2013 [S15]
Home visit during pregnancy	Household income	Equitable	Callaghan–Koru 2013 [S15]
Azythromycin distribution to entire communities for trachoma	Household assets	Pro–equitable	Cumberland 2008 [S19]
CHW visit to caregivers within the past year	Urban vs rural	Pro–equitable	Litrell 2013 [S25]
Caregivers report of CHWs working in community	Urban vs rural	Pro–equitable	Litrell 2013 [S25]
Prenatal home visit	Household income	Pro–equitable	Baqui 2008 [S8]
Number of home visits	Urban vs rural	Pro–equitable	Perry 2006 [S35]
Antenatal home visit	Household income	Pro–equitable	Baqui 2008 [S8]
At least one home visit during pregnancy	Household income	Pro–equitable	Callaghan–Koru 2013 [S15]
Two or more home visits during pregnancy	Household income	Pro–equitable	Callaghan–Koru 2013 [S15]
Home visits to support breastfeeding	Household income, maternal education	Pro–equitable	Coutinho 2005 [S17]
Child ill and CHW called to come to the home	Household income	Pro–equitable	Siekmans 2013 [S38]
At least one ANC visit in home	Household income	Pro–equitable	Nonyane 2015 [S32]

*References which are prefixed with an S appear in Appendix S1 of the **online supplementary document**.

this portion of the log frame consistently support the equitable nature of home visiting practices, a central feature of many CBPHC projects, as also discussed in the in this supplement that directly address the effectiveness of CBPHC in improving MNCH [30–32]. Many of these home visits either implicitly or explicitly included promotion and support of breastfeeding, which has also been noted in the literature as an intervention that can be supported equitably through community–based approaches with multiple benefits to MNCH.

Assessments of equity of outputs

The assessments of equity using output indicators are listed in **Table 4**. Two–thirds (4/6) of the six equity assessments using output indicators among the projects selected for our analysis concerned the utilization of specific services or the expected immediate output of an intervention. Half (3/6) of these equity assessments used household income as the equity criterion. The number of assessments is too small to make major generalizations from, but the indicators demonstrating a pro–equity effect in the output category focus on access to health services (either in a facility or in the home). Indicators that demonstrated an inequitable effect were both from the same study and related to the hygienic practices across several equity dimensions.

Assessments of equity of outcomes

Table 5 below lists the equity assessments carried out using outcome indicators. Many relate to knowledge and behavior change related to breastfeeding or to the population coverage level of an intervention. Of the 35 measurement carried out, only 14% (5/35) yielded an inequitable result; 11% (4/35) yielded an equitable result, and the rest (74%) yielded a pro–equitable result. Inequitable indicators included several interventions requiring significant equipment or knowledge such as vaccine coverage and antenatal and delivery care. Some indicators — such as ITN coverage, availability, and use — showed mixed results across different studies, with some having equitable results across household income categories or urban and rural settings and others not. Equitable and pro–equitable programs commonly focused on equitable behaviors such as breastfeeding and newborn and child health practices that can be implemented in the home without complex or expensive supplies or knowledge.

Table 4. Assessments of equity effects of CBPHC projects using output indicators*

Output indicator	Equity criterion	Outcome	Reference
Food hygiene score in relation to cleanliness score	Household income	Inequitable	Ahmed 1993 [S1]
Food hygiene score in relation to diarrhea prevalence	Maternal education, nutritional status	Inequitable	Ahmed 1993 [S1]
Utilization of ambulatory care facility	Urban vs rural	Pro–equitable	Perry 2006 [S35]
Number of hospital admissions	Urban vs rural	Pro–equitable	Perry 2006 [S35]
Child with fever treated within 24 h	Household income	Pro–equitable	Siekmans 2013 [S38]
Essential newborn practices performed	Household income	Pro–equitable	Baqui 2008 [S8]

*References which are prefixed with an S appear in Appendix S1 of the **online supplementary document**.

Table 5. Assessments of equity effects of CBPHC projects using outcome indicators*

Outcome indicator	Equity criterion	Outcome	Reference
Understanding of overall cleanliness	Maternal education	Inequitable	Ahmed 1993 [S1]
Coverage of antenatal and delivery care	Household income	Inequitable	Bryce 2008 [S14]
EPI immunization coverage	Household income	Inequitable	Webster 2005 [S42]
ITN coverage	Household income	Inequitable	Webster 2005 [S42]
Coverage of any type of bed net (ITN or other)	Household income	Inequitable	Webster 2005 [S42]
Health service coverage	Child's sex	Equitable	Bryce 2008 [S14]
Nothing applied to umbilical cord by mother after birth	Household income	Equitable	Nonyane 2015 [S32]
Child with diarrhea treated with ORS or zinc	Household income	Equitable	Littrell 2013 [S25]
Awareness of support group in community	Household income	Equitable	Callaghan–Koru 2013 [S15]
Exclusive breastfeeding	Urban vs rural	Pro–equitable	Crookston 2000 [S18]
Exclusive breastfeeding from birth to 6m	Household income	Pro–equitable	Coutinho 2005 [S17]
Breastfeeding initiation within first hour of life	Urban vs rural	Pro–equitable	Crookston 2000 [S17]
Breastfeeding initiation within first hour of life	Household income	Pro–equitable	Nonyane 2015 [S32]
Knowledge of family planning methods	Urban vs rural	Pro–equitable	Debpuur 2002 [S20]
Knowledge and use of family planning	Maternal education, social standing	Pro–equitable	Awooner–Williams 2004 [S5]
Recognition of at least 3 danger signs in newborns	Household income	Pro–equitable	Nonyane 2015 [S32]
Child with fever treated with artemether–lumefantrine within 48 hours	Household income	Pro–equitable	Siekmans 2013 [S38]
Acute respiratory infection treatment rate	Household income	Pro–equitable	Mercer 2004 [S28]
Any bed net available	Household income	Pro–equitable	Skarbinski 2007 [S39]
Measles vaccination rate	Household income	Pro–equitable	Mercer 2004 [S28]
Immunization coverage	Household income	Pro–equitable	Bawah 2006 [S10]
ITN in home	Household income	Pro–equitable	Skarbinski 2007 [S39]
ITN coverage	Urban vs rural	Pro–equitable	Grabowsky 2005 [S23]
ITN coverage	Household income	Pro–equitable	Grabowsky 2005 [S23]
ITN coverage	Household income	Pro–equitable	Noor 2007 [S33]
Immediate drying	Household income	Pro–equitable	Nonyane 2015 [S32]
Postnatal care coverage	Maternal education, household income, social standing, household assets	Pro–equitable	Awooner–Williams 2004 [S5]
Children sleeping under ITNs	Household income	Pro–equitable	Noor 2007 [S33]
Attended delivery	Maternal education, household income, social standing, household assets	Pro–equitable	Awooner–Williams 2004 [S5]
Antenatal care	Maternal education, household income, social standing, household assets	Pro–equitable	Awooner–Williams 2004 [S5]
Antenatal care coverage	Household income	Pro–equitable	Baqui 2008 [S8]

*References which are prefixed with an S appear in Appendix S1 of the **online supplementary document**.

Assessments of equity of health impact

Finally, **Table 6** lists the assessments of health equity that were carried out for health impact–related indicators (nutritional status, morbidity or mortality). Of the 28 projects that included an equity assessment of health impact, 20 were based on a measure of mortality; four were based on a measure of morbidity and four on a measure of nutritional status. Overall, 23 of the 28 assessments demonstrated pro–equitable results and one yielded an equitable result. Only four of the 28 yielded an inequitable result.

Overall summary of equity effects using household wealth as the equity criterion

We have summarized all the findings reported above in which household income was the equity criterion (**Table 7**). Overall, 75% (33/44) of these effects were pro–equitable outcome, 9% were equitable outcomes, and only 16% (7/44) yielded an inequitable effect.

Overall summary of all equity effects

Finally, we have summarized equity effects in **Table 8**. Overall, 78% (64/82) of the equity assessments carried out yielded a pro–equitable outcome; 9% (7/82) yielded an equitable outcomes, and only 13% (11/82) yielded an inequitable outcome.

While in–depth analysis of the impact of packages of interventions was not the focus of this paper (another paper in this series [33] addresses this strategy in general – not limited to equity), we reviewed which projects constituted a single intervention vs a package of interventions. Of the 42 projects, 11

Table 6. Assessments of equity of CBPHC projects using impact indicators*

Impact indicator	Equity criterion	Outcome	Reference
Neonatal morality rate	Household income	Inequitable	Razzaque 2007 [S36]
Under–5 mortality rate	Urban vs rural	Inequitable	Bryce 2008 [S14]
Under–5 mortality rate	Household income	Inequitable	Razzaque 2007 [S36]
Child (age 6–59 months) mortality rate	Social standing, child's sex	Inequitable	Bishai 2005 [S12]
Tetanus neonatorum mortality rate	Urban vs rural	Equitable	Newell 1966 [S31]
Diarrhea prevalence in children 0–36 months of age	Urban vs rural	Pro–equitable	Barreto 2007 [S9]
Diarrhea prevalence in children 0–18 months of age	Nutritional status	Pro–equitable	Ahmed 1993 [S1]
Diarrhea prevalence in children 0–36 months of age	Urban vs rural	Pro–equitable	Barreto 2007 [S9]
Undernutrition prevalence	Nutritional status	Pro–equitable	Mustaphi 2005 [S30]
Child nutrition status (qualitative data)	Nutritional status	Pro–equitable	McNelly 1998 [S29]
Perinatal mortality rate	Urban vs rural	Pro–equitable	Bang 2005 [S7]
Perinatal mortality rate	Urban vs rural	Pro–equitable	Bang 1999 [S6]
Neonatal mortality rate	Urban vs rural	Pro–equitable	ASHA–India 2008 [S4]
Neonatal mortality rate	Urban vs rural	Pro–equitable	Bang 1999 [S6]
Infant mortality rate	Maternal education, child's sex	Pro–equitable	Fegan 2007 [S21]
Infant mortality rate	Urban vs rural	Pro–equitable	Asha–India 2008 [S4]
Infant mortality rate	Social standing, parental occupation	Pro–equitable	Bang 1999 [S6]
Infant mortality rate	Household income	Pro–equitable	Bhuiya 2002 [S11]
Infant mortality rate	Household assets, maternal education	Pro–equitable	Bang 2005 [S7]
Infant mortality rate	Human development index	Pro–equitable	Aquino 2009 [S2]
Infant mortality rate	Household income	Pro–equitable	Mercer 2004 [S28]
Infant, 1–4 years, and under–5 mortality rates	Household income	Pro–equitable	Mercer 2004 [S28]
Under–5 mortality rate	Household income	Pro–equitable	Sepulveda 2006 [S37]
Under–5 mortality rate	Urban vs rural, household income	Pro–equitable	Asha–India 2008 [S4]
Under–5 mortality rate	Urban vs rural	Pro–equitable	Perry 2006 [S35]
Under–5 mortality rate	Household income	Pro–equitable	Bryce 2008 [S14]
Under–5 mortality rate	Urban vs rural	Pro–equitable	Asha–India 2008 [S4]

*References which are prefixed with an S appear in Appendix S1 of the **online supplementary document**.

Table 7. Summary of assessments of equity using socio–economic status or household wealth quintile as the equity criterion

Type of indicator	Effect on equity			
	Inequitable	Equitable	Pro–equitable	Total
Input	0	0	0	0
Process	0	2	7	9
Output	1	0	2	3
Outcome	4	2	18	24
Impact	2	0	6	8
Total	7	4	33	44

Table 8. Summary of all assessments of equity

Type of indicator	Effect on equity			
	Inequitable	Equitable	Pro–equitable	Total
Input	0	0	0	0
Process	0	2	11	13
Output	2	0	4	6
Outcome	5	4	26	35
Impact	4	1	23	28
Total	11	7	64	82

(26%) included a single intervention while eight (19%) included 2 interventions, and 23 (55%) of projects had a package of three or more services. We could not identify any clear patterns between the number of interventions and how equitable the findings were; the only clear pattern was that, in general, all interventions and equity dimensions within any particularly project tended to be the same in terms of equity outcomes (eg, all of the findings for Ahmed 1993 were inequitable).

Of the 42 projects that conducted an equity analysis, we also reviewed which ones analyzed more one or more dimensions of equity. 27 (64%) included an analysis for only one dimension of equity while nine (21%) included two dimensions of equity, and only six (14%) included three or more dimensions of equity. We also did not identify any obvious patterns among the small groups of projects in each of these categories. Household income as part of SES was by far the most common dimension of equity, and was utilized across all of these categories followed closely by comparing urban vs rural populations. The projects with inequitable findings included a number of SES analyses and also child gender and an urban vs rural comparison.

DISCUSSION

We have carried out an equity analysis of the projects in our review that contained evidence regarding the equity effects of CBPHC in improving child health. Out of the 546 assessments related to child health in our data set, 42 measured equity effects. Of the 82 measurements of equity effects in these 42 projects, 87% of these measurements indicated that the equity effect was either equitable (in which the disadvantage group benefitted to the same degree as the more advantaged group) or pro–equitable (in which the disadvantaged group benefitted more). Of the 42 articles in our review, 15 of them (36%) measured two or more equity dimensions and 31 articles (74%) measured equity across two or more interventions. These findings provide strong evidence of the capacity of CPBHC to reduce inequities in the delivery of child health services and in child health outcomes. Thus, these findings are consistent with the assertion that CBPHC has the potential to reduce inequities in child health in low–income settings where health facilities alone would be highly unlikely to reduce existing inequities since, in fact, it is well–known that health facility utilization in low–income settings is highly inequitable, as explained further below.

The counter–argument to this assertion is that expansion of the number of facilities and improvements in facility–based care will eventually reduce inequities in child health. This may be possible in the very long term, but there is no evidence at present that we are aware of demonstrating that expanding or improving facility–based services as an isolated strategy reduces inequities in the delivery of child health services or in child health status. For the near term, resources will continue to be highly constrained in low–income countries and major geographic [34], social and financial barriers will continue to exist in accessing facility–based care. Therefore, our findings indicate that strong expansion of CBPHC will be required to reduce inequities in child health.

A case example from Brazil of equity effects of CBPHC on improving child health (an article selected from database) serves as an example of the potential pro–equity effects of combining community–based approaches with political will and investment, a national strategy, and a long-term commitment).

Aquino et al., 2008 (reference [S12] in **Online Supplementary Document**) analyzed the effects of expanding Brazil's Family Health Program (FHP) coverage on infant mortality. They identified that the effect of the FHP program was greatest in terms of decreasing infant mortality in municipalities where infant mortality was highest and the human development index was lowest at the beginning of the study period. The FHP program used a family–centered approach to provide a range of services at the community level, including promotion of breastfeeding, prenatal care, immunizations, and management of diarrhea. The team of health workers, in addition to physicians and nurses as well as oral health professionals, includes CHWs (called Community Health Agents) who visited every home on a monthly basis. This national program has brought Brazil global recognition for its efforts to reduce health inequities for the general population and for children in particular (including inequities of childhood nutritional status). A high level of political will has been necessary in order to implement the scale and depth of this program at the national level.

Explaining the pro–equity effects of community–based primary health care

Most CBPHC projects are designed to reach every household with health education and information about how to access outreach services (if not to actually provide services including curative care), and outreach services are generally distributed more evenly throughout target populations than facility–based services [35]. Meanwhile, some countries, such as Peru, where great investment in health facilities has taken place—including expansion of community health centers—these efforts have resulted in only very small improvements on equitable utilization of health facilities [36].

Research on the equity of facility utilization in low–income settings is limited; more evidence is available for high–income settings in the Americas, Europe, and Asia. In LMIC settings, health facilities tend to be few and far between, often expensive from the perspective of the poor, and lacking high quality of care, including provision of care that is seen by certain sub–groups as disrespectful [36–38]. Factors such as education level, income, and urban and rural residence play key roles in determining whether someone is more or less likely to seek care at a health facility [36,37]. Thus, the effort and resources that patients and their families have to expend to reach a health facility and the uncertain return on that family's investment contributes to low utilization of facility–based services.

The challenge of providing interventions that are often only available in health facilities – or require infrastructure and skills difficult to deploy in communities outside of facilities—is significant as well. A growing literature, including but also going beyond the database used in this study, points to inequitable usage of health facilities in terms of the SES and urban/rural characteristics of users [23,34,39].

The need for alternative approaches beyond health facilities to achieve equity in and in fact universal coverage for child health are the following: (i) there is an exponential decline in the utilization of health facilities with increasing distance to the health facility (particularly more than 5 km or 1 hour walk away) [35], and (ii) there is a need for available and affordable public transportation in order to reach health facilities, which is often absent [33,39]. What is lacking from the literature are in–depth assessments of equity of health care utilization in terms of distance from a health facility and the effect of distance from health facilities on health status, taking into account also whether community–based care is available to those further away from those facilities.

Strong community–based programs can encourage facility utilization across income strata as can vouchers provided at the community level for specific services, such as antenatal care, to reduce resource barriers to seeking care [40]. The available evidence suggests that CBPHC approaches that reach all households can be more equitable than solely facility–based approaches in terms of coverage of a number of key primary health care services, particularly for vulnerable populations and those who live further away from facilities, who are also usually more disadvantaged in terms of SES [20,41–43].

There are several assessments that directly compare the degree to which CBPHC approaches as opposed to other approaches improve the health of the poorest segment of the project population compared to hat of the better off segment. It makes sense that home–centered, low–resource interventions like breastfeeding promotion and distribution of ITNs would be able to achieve high levels of equity through community–based approaches that often include direct contact with all households [7]. In addition, some of the most promising strategies to improve health equity focus on strengthening community outreach, using CHWs and other lay workers, along with market–driven options such as minimizing or removing user fees and engaging the private sector [3,44,45].

Approaches that make it possible for health workers to reach all households – or at least to reach outreach points that are relatively evenly distributed throughout the project population and close to homes – are inherently more likely to achieve favorable equity effects than facility–based approaches. However, a number of other equity–relevant factors including education, child's sex, ethnicity [46], and urban vs rural contexts [47] cannot be overlooked even within such a strong outreach approach [48]. Health programs in high–mortality, resource–constrained settings lack the capacity to build and operate facilities within easy reach of all who could need to use them – particularly in low–density rural areas. Thus, the decentralization of services and utilization of innovative and proven strategies to support the coverage, quality, and sustainability of those services is essential for achieving health equity.

While the focus of this review is on low–income countries, inequities are also prevalent in higher–income countries as well. Even where more resources are available to address such issues, political will is needed to direct those resources in ways that decrease inequities. An example of progress and success in the arena of health equity is Japan's national policies to provide equitable educational opportunities as well as access to health services without financial barriers [49]. Globally, but particularly in low–income countries, much work remains to be done to make this kind of progress a reality for all populations. In addition to our public health–specific tools and approaches, more comprehensive community development and empowerment frameworks, such as the CHOICE (**C**apacity–building, **H**uman rights, **O**rganizational sustainability, **I**nstitutional accountability, **C**ontribution, and **E**nabling environment) framework [50], can help to frame issues of health equity and provide additional entry points for understanding and addressing them. As Victora et al. note [51], just using the data available and recognizing patterns in inequities is not enough; political will and deliberate design and attention to the causes of inequities in programs for child health are necessary to achieve substantial decreases in child mortality among the most disadvantaged sub–populations where the mortality rates are the greatest.

Community–based approaches can reach those furthest from health facilities and can rapidly expand population coverage of key interventions, so these findings are not surprising. These findings stand in stark contrast to the commonly observed finding that utilization of primary health care facilities is inequitable because those in the lower income quintiles are less likely to obtain services there [52,53]. To our knowledge, this is the first comprehensive review in the peer–reviewed literature summarizing the equity effects of CBPHC in improving child health.

Limitations of our study

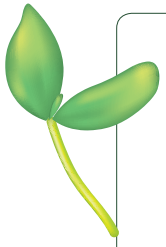
This study has several limitations that we want to make explicit. First, we have not further disaggregated the articles based on how strong the equity effect is. Second, some of the 42 assessments qualifying for

our analysis are efficacy studies conducted within community settings in which ideal conditions were present for project implementation. Therefore, we must be careful about generalizing these findings to everyday practice settings. But, that said, it still remains true that strong pro–equity effects are achievable through CBPHC. An analysis of the quality of the data included in the 42 assessments included in our review was beyond the scope of this article. Finally, although a thorough search has been conducted that covers articles published over the past six decades through the end of 2015, we know that there are likely to be more recent articles published since that time that are relevant to this analysis.

We have worked to be clear in our language, conservative in our claims, and yet optimistic about the role of community–based approaches to continue to help bolster health equity for children in disadvantaged populations around the world.

CONCLUSIONS

Based on the finding that the services provided by CBPHC projects generally reach most or all households and are readily accessible throughout the project population, CBPHC projects are inherently more likely to achieve pro–equity effects than projects that strengthen services only at facilities. The decentralization of service provision and management and the utilization of community–level workers are important for reducing inequities in national programs of countries where the risk of child mortality is high. Equity assessments need to become a standard feature of MNCH programming.



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REFERENCES

1 Moore A. Tracking Down Martin Luther King, Jr.'s Words on Health Care. 2013. Available: http://www.huffingtonpost.com/amanda-moore/martin-luther-king-health-care_b_2506393.html. Accessed: 20 March 2017.

2 Barros AJ, Victora CG. Measuring Coverage in MNCH: determining and interpreting inequalities in coverage of maternal, newborn, and child health interventions. PLoS Med. 2013;10:e1001390. Medline:23667332 doi:10.1371/journal.pmed.1001390

3 McCollum R, Gomez W, Theobald S, Taegtmeyer M. How equitable are community health worker programmes and which programme features influence equity of community health workers services? A systematic review. BMC Public Health. 2016;16:419. Medline:27207151 doi:10.1186/s12889-016-3043-8

4 Requejo J, Victora C, Bryce J. A Decade of Tracking Progress for Maternal, Newborn, and Child Survival: The 2015 Report. Baltimore, MD: Johns Hopkins University, 2015.

5 Barros AJ, Ronsmans C, Axelson H, Loaiza E, Bertoldi AD, Franca GV, et al. Equity in maternal, newborn, and child health interventions in Countdown to 2015: a retrospective review of survey data from 54 countries. Lancet. 2012;379:1225-33. Medline:22464386 doi:10.1016/S0140-6736(12)60113-5

6 Requejo JH, Bryce J, Barros AJ, Berman P, Bhutta Z, Chopra M, et al. Countdown to 2015 and beyond: fulfilling the health agenda for women and children. Lancet. 2015;385:466-76. Medline:24990815 doi:10.1016/S0140-6736(14)60925-9

7 Barros AJ, Ronsmans C, Axelson H, Loaiza E, Bertoldi A. Equity in Maternal, Newborn, and Child Health Interventions in Countdown to 2015: A Retrospective Review of Survey Data from 54 Countries. Lancet. 2012;379:1225-33. Medline:22464386 doi:10.1016/S0140-6736(12)60113-5

8 Victora CG, Requejo JH, Barros AJ, Berman P, Bhutta Z, Boerma T, et al. Countdown to 2015: a decade of tracking progress for maternal, newborn, and child survival. Lancet. 2016;387:2049-59. Medline:26477328 doi:10.1016/S0140-6736(15)00519-X

9 World Federation of Public Health Associations. The Addis Ababa Declaration on Global Health Equity: A Call To Action. 2012. Available: http://www.wfpha.org/tl_files/doc/about/Addis_Declaration.pdf. Accessed: 20 March 2017.

10 Countdown 2008 Equity Analysis Group, Boerma JT, Bryce J, Kinfu Y, Axelson H, Victora CG. Mind The Gap: equity and trends in coverage of maternal, newborn, and child health services in 54 Countdown Countries. Lancet. 2008;371:1259-67. Medline:18406860 doi:10.1016/S0140-6736(08)60560-7

11 Victora CG, Barros A, Axelson H, Bhutta J, Chopra M, Franca G, et al. How changes in coverage affect equity in maternal and child health interventions in 35 Countdown to 2015 countries: an analysis of national surveys. Lancet. 2012;380:1149-56. Medline:22999433 doi:10.1016/S0140-6736(12)61427-5

12 Barros AJ, Ronsmans C, Axelson H, Loaiza E, Bertoldi AD, França GV, et al. Equity in maternal, newborn, and child health interventions in Countdown to 2015: a retrospective review of survey data from 54 countries. Lancet. 2012;379:1225-33. Medline:22464386 doi:10.1016/S0140-6736(12)60113-5

13 UNICEF, World Health Organization. A Decade of Tracking Progress for Maternal, Newborn and Child Survival: The 2015 Report. 2015. Available: http://www.countdown2015mnch.org/documents/2015Report/Countdown_to_2015_final_report.pdf. Accessed: 20 March 2017.

14 Braveman P. Health disparities and health equity: concepts and measurement. Annu Rev Public Health. 2006;27:167-94. Medline:16533114 doi:10.1146/annurev.publhealth.27.021405.102103

15 Taylor CE. Surveillance for equity in primary health care: policy implications from international experience. Int J Epidemiol. 1992;21:1043-9. Medline:1483808 doi:10.1093/ije/21.6.1043

16 World Health Organization. Closing the Gap in a Generation: Health Equity Through Action on the Social Determinants of Health. Geneva: World Health Organization; 2008.

17 Hofman K, Blomstedt Y, Addei S, Kalage R, Maredza M, Sankoh O, et al. Addressing research capacity for health equity and the social determinants of health in three African countries: the INTREC Programme. Glob Health Action. 2013;6:19668. doi:10.3402/gha.v6i0.19668

18 Marmot M, Bell R. Social inequalities in health: a proper concern for epidemiology. Ann Epidemiol. 2016;26:238-40. Medline:27084546 doi:10.1016/j.annepidem.2016.02.003

19 Barros F, Victora C, Scherpbier R, Gwatkin D. Health and Nutrition of Children: Equity and Social Determinants. In: Blas E, Kurup AS, editors. Equity, Social Determinants, and Public Health Programmes. Geneva: World Health Organization; 2010.

20 Gilmour S, Shibuya K. Simple steps to equity in child survival. BMC Med. 2013;11:261. Medline:24344755 doi:10.1186/1741-7015-11-261

21 Afsana K, Haque MR, Sobhan S, Shahin SA. BRAC's Experience in scaling-up MNP in Bangladesh. Asia Pac J Clin Nutr. 2014;23:377-84. Medline:25164447

22 World Health Organization. Ending Preventable Child Deaths from Pneumonia and Diarrhea by 2025: The Integrated Global Action Plan for Pneumonia and Diarrhea (GAPPD). Geneva: World Health Organization; 2013.

23 Perry HB, King-Schultz L, Aftab A, Bryant J. Health equity issues at the local level: socio-geography, access, and health outcomes in the service area of the Hôpital Albert Schweitzer-Haiti. Int J Equity Health. 2007;6:7. Medline:17678540 doi:10.1186/1475-9276-6-7

24 Perry H, Rassekh B, Gupta S, Wilhelm J, Freeman P. A comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 1. rationale, methods and database description. J Glob Health. 2017;7:010901.

25 Welch V, Tugwell P, Petticrew M, de Montigny J, Ueffing E, Kristjansson B, et al. How effects on health equity are assessed in systematic reviews of interventions. Cochrane Database Syst Rev. 2010;MR000028. Medline:21154402

26 Welch V, Petticrew M, Tugwell P, Moher D, O'Neill J, Waters E, et al. PRISMA-Equity 2012 extension: reporting guidelines for systematic reviews with a focus on health equity. PLoS Med. 2012;9:e1001333. Medline:23222917 doi:10.1371/journal.pmed.1001333

27 Winestock-Luna J, Victora C. Considerations for Incorporating Health Equity into Project Designs: A Guide for Community-Oriented Maternal, Neonatal, and Child Health Projects. Washington, DC: USAID, 2011.

28 Gwatkin DR. 10 Best resources on...health equity. Health Policy Plan. 2007;22:348-51. Medline:17698890 doi:10.1093/heapol/czm028

29 Bryce J, Victora CG, Boerma T, Peters DH, Black RE. Evaluating the scale-up for maternal and child survival: a common framework. Int Health. 2011;3:139-46. Medline:24038362 doi:10.1016/j.inhe.2011.04.003

30 Jennings MC, Pradhan S, Schleiff M, Sacks E, Freeman P, Gupta S. A comprehensive review of the evidence regarding the effectiveness of Community-based Primary Health Care in improving maternal, neonatal, and child health: 2.Maternal health Findings. J Glob Health. 2017;7:010902.

31 Sacks E, Freeman P, Jennings MC, Rassekh B, Gupta S, Perry H. A comprehensive review of the evidence regarding the effectiveness of Community-based Primary Health Care in improving maternal, neonatal, and child health: 3. neonatal health findings. J Glob Health. 2017;7:010903.

32 Freeman P, Schleiff M, Sacks E, Rassekh B, Gupta S, Perry H. A comprehensive review of the evidence regarding the effectiveness of Community-based Primary Health Care in improving maternal, neonatal, and child health: 4. child health findings. J Glob Health. 2017;7:010904.

33 Perry H, Rassekh B, Gupta S, Freeman P. A comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 6. strategies used by effective projects. J Glob Health. 2017;7:010906.

34 Tanser F, Gijsbertsen B, Herbst K. Modelling and understanding primary health care accessibility and utilization in rural South Africa: an exploration using a Geographical Information System. Soc Sci Med. 2006;63:691-705. Medline:16574290 doi:10.1016/j.socscimed.2006.01.015

35 Houweling TA, Tripathy P, Nair N, Rath S, Rath S, Gope R, et al. The equity impact of participatory women's groups to reduce neonatal mortality in India: secondary analysis of a cluster-randomised trial. Int J Epidemiol. 2013;42:520-32. Medline:23509239 doi:10.1093/ije/dyt012

36 Valdivia M. Public health infrastructure and equity in the utilization of outpatient health care services in Peru. Health Policy Plan. 2002;17 Suppl:12-9. Medline:12477737 doi:10.1093/heapol/17.suppl_1.12

37 Alberts JF, Sanderman R, Eimers JM, van den Heuvel WJ. Heuler Wvd. Socioeconomic inequity in health care: a study of services utilization in Curaçao. Soc Sci Med. 1997;45:213-20. Medline:9225409 doi:10.1016/S0277-9536(96)00338-3

38 Bohren MA, Vogel J, Hunter E, Lutsiv O, Makh S, Souza JP, et al. The mistreatment of women during childbirth in health facilities globally: a mixed-methods systematic review. PLoS Med. 2015;12:e1001847. Medline:26126110 doi:10.1371/journal.pmed.1001847

39 Tappis H, Koblinsky M, Doocy S, Warren N, Peters D. Bypassing primary care facilities for childbirth: findngs from a multilevel analysis of skills birth attendance determinants in Afghanistan. J Midwifery Womens Health. 2016;61:185-95. Medline:26861932 doi:10.1111/jmwh.12359

40 Ahmed S, Khan MM. Is demand-side financing equity enhancing? Lessons from a maternal health voucher scheme in Bangladesh. Soc Sci Med. 2011;72:1704-10. Medline:21546145 doi:10.1016/j.socscimed.2011.03.031

41 Baqui AH, Rosecrans AM, Williams EK, Agarwal PK, Ahmed S, Darmstadt G. NGO facilitation of a government community-based maternal and neonatal health programme in rural India: improvements in equity. Health Policy Plan. 2008;23:234-43. Medline:18562458 doi:10.1093/heapol/czn012

42 Kumar V, Kumar A, Das V, Srivastava N, Baqui A, Darmstadt G. Community-driven impact of a newborn-focused behavioral intervention on maternal Health in Shivarg, India. Int J Gynaecol Obstet. 2012;117:48-55. Medline:22281244 doi:10.1016/j.ijgo.2011.10.031

43 World Bank. Analyzing Health Equity: Introduction. 2008. Available: https://openknowledge.worldbank.org/handle/10986/6896. Accessed: 26 April 2017.

44 Chopra M, Sharkey A, Dalmiya N, Anthony D, Birkin N. Strategies to improve health coverage and narrow the equity gap in child survival, health, and nutrition. Lancet. 2012;380:1331-40. Medline:22999430 doi:10.1016/S0140-6736(12)61423-8

45 Winestock Luna J, Monga T, Morgan L. Equity matters–lessons from MCHIP and CSHGP in Measuring and Improving Equity. Washington, DC: USAID/MCHIP, 2014.

46 Anderson LM, Adeney K, Shinn C, Safranek S, Buckner-Brown J, Krause LK. Community coalition-driven interventions to reduce health disparities among racial and ethnic minority populations. Cochrane Database Syst Rev. 2015;6:CD009905. Medline:26075988

47 Scheil-Adlung X. Global evidence on inequities in rural health protection: new data on rural deficits in health coverage for 174 countries. Extension of Social Security. 2015. Available: http://www.social-protection.org/gimi/gess/RessourcePDF.action?ressource.ressourceId=51297. Accessed: 26 April 2017.

48 Lassi Z, Kumar R, Bhutta Z. Community-based Care to Improve Maternal, Newborn, and Child Health. In: Black R, Laxminarayan R, Temmerman M, walker N, editors. Reproductive, Maternal, Newborn, and Child Health. 3rd ed. Washington DC; World Bank Group: 2016.

49 Ikeda N, Saito E, Kondo N, Inoue M, Ikeda S, Satoh T, et al. What has made the population of Japan Healthy? Lancet. 2011;378:1094-105. Medline:21885105 doi:10.1016/S0140-6736(11)61055-6

50 Rifkin SB. A framework linking community empowerment and health equity: it is a matter of CHOICE. J Health Popul Nutr. 2003;21:168-80. Medline:14717563

51 Victora CG, Wagstaff A, Schellenberg JA, Gwatkin D, Claeson M, Habicht J-P. Applying an equity lens to child health and mortality: more of the same is not enough. Lancet. 2003;362:233-41. Medline:12885488 doi:10.1016/S0140-6736(03)13917-7

52 Szwarcwald CL, Souza-Junior PR, Damacena GN. Socioeconomic inequalities in the use of outpatient services in Brazil according to health care need: evidence from the World Health Survey. BMC Health Serv Res. 2010;10:217. Medline:20653970 doi:10.1186/1472-6963-10-217

53 Malik SM, Ashraf N. Equity in the use of public services for mother and newborn child health care in Pakistan: a utilization incidence analysis. Int J Equity Health. 2016;15:120. Medline:27459961 doi:10.1186/s12939-016-0405-x

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Comprehensive review of the evidence regarding the effectiveness of community–based primary health care in improving maternal, neonatal and child health: 6. strategies used by effective projects

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Background As part of our review of the evidence of the effectiveness of community–based primary health care (CBPHC) in improving maternal, neonatal and child health (MNCH), we summarize here the common delivery strategies of projects, programs and field research studies (collectively referred to as projects) that have demonstrated effectiveness in improving child mortality. Other articles in this series address specifically the effects of CBPHC on improving MNCH, while this paper explores the specific strategies used.

Methods We screened 12 166 published reports in PubMed of community–based approaches to improving maternal, neonatal and child health in high–mortality, resource–constrained settings from 1950–2015. A total of 700 assessments, including 148 reports from other publicly available sources (mostly unpublished evaluation reports and books) met the criteria for inclusion and were reviewed using a data extraction form. Here we identify and categorize key strategies used in project implementation.

Results Six categories of strategies for program implementation were identified, all of which required working in partnership with communities and health systems: (a) program design and evaluation, (b) community collaboration, (c) education for community–level staff, volunteers, beneficiaries and community members, (d) health systems strengthening, (e) use of community–level workers, and (f) intervention delivery. Four specific strategies for intervention delivery were identified: (a) recognition, referral, and (when possible) treatment of serious childhood illness by mothers and/or trained community agents, (b) routine systematic visitation of all homes, (c) facilitator–led participatory women's groups, and (d) health service provision at outreach sites by mobile health teams.

Conclusions The strategies identified here provide useful starting points for program design in strengthening the effectiveness of CBPHC for improving MNCH.

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In recent decades, much of the funding for global health has concentrated on technical cooperation pertaining to strengthening narrowly focused vertical programs, such as control of HIV, malaria and tuberculosis, and expanding immunization coverage. However, in order to accelerate progress in the reduction of readily preventable deaths of children and mothers, there have been calls for more direct funding for integrated maternal and

child health programs [1], health systems strengthening [2], integration of key interventions via a continuum of care [3,4], and stronger community participation [5]. However, none of these calls have sufficiently emphasized the importance of strengthening community–based service delivery strategies for accelerating progress by achieving high levels of coverage of evidence–based interventions. Too often, attention has been focused on the technical aspects of interventions rather than on the strategies and support systems that are needed to achieve high levels of population coverage.

Previous reviews have highlighted family and community practices that are important for maternal, newborn and child health [6] as well as specific technical interventions that can be provided in communities [7–10], but none have to date focused specifically on the implementation strategies that effective projects have used. This paper summarizes the various approaches used by the programs, projects and studies (hereafter referred to as projects) whose effectiveness has been assessed and included in a comprehensive database.

METHODS

We conducted a comprehensive review of the effectiveness of community–based primary health care (CBPHC) in improving maternal, newborn and child health (MNCH) by reviewing 12 186 published reports of community–based programs for improving MNCH in low– and middle–income countries. 552 of these reports qualified. An additional 148 reports were identified from the "grey" literature (documents publicly available on the internet) and books. A total of 700 assessments were included in this review. A full description of the search strategy and creation of the database is available elsewhere [11].

Of particular importance for this paper is that a data extraction form was designed to capture as much information as possible in the document containing the project's assessment that describes the project strategies and what role the community played. We did not attempt to force any strict definition of the term "community" in the analysis of the findings since there was no uniform definition used in the projects or by the reviewers. By strategies we mean the activities that these projects used to make the intervention effective – to plan the project, engage partners (including the community), implement the project, engage in associated activities not directly related to intervention delivery, and evaluate the project. The data extraction forms used to collect information from the assessments were designed to capture the available information regarding strategies used for project implementation. In particular, open–ended descriptions of project implementation were completed by reviewers.

A copy of the data extraction form is contained in Online Supplementary Document of the above–mentioned paper [11]. The form allows for open–ended as well as close–ended responses related to strategies and community engagement. Data were extracted from each assessment by two independent reviews and a third reviewer resolved any differences between the first two reviews.

The maternal, neonatal and child health database was searched carefully to identify all information that described the strategies that were used by projects. All available evidence in the database regarding strategies for project implementation was reviewed by reviewing all the open–responses individually and summarizing common themes as well as by adding up the number of responses to close–ended questions.

RESULTS

We identified six categories of strategies used by the projects in our database: (a) program design and evaluation, (b) community collaboration, (c) education for community–level staff, volunteers, beneficiaries and community members, (d) health systems strengthening, (e) use of community–level volunteers and workers (hereafter referred to as community health workers, or CHWs), and (f) intervention delivery. **Table 1** summarizes these strategies. The strategies were not mutually exclusive and most projects used at least several of these strategies and, in fact, some of the strategies fit into several categories (eg, participatory women's groups).

Strategies for program design and evaluation

Strategies for project design and evaluation shown in **Table 1** often included baseline and endline knowledge, practice and coverage (KPC) population–based household surveys. These made it possible to measure changes in intervention coverage in the program population as well as changes in childhood nutri-

Table 1. Summary of strategies used by CBPHC projects to improve child health

Category of strategy	Specific strategy
Program design and evaluation	Knowledge, practice and coverage (KPC) household surveys
	Participatory Rural Appraisal (PRA)
	Village rosters of beneficiaries
	Census–taking
	Disease surveillance (based on information provided by community–based workers and communities)
	Prospective registration of vital events (pregnancies, births and deaths)
	Retrospective mortality assessment (based on maternal birth histories)
	Determination of cause of death from verbal autopsies
	Engagement of communities in planning and evaluation
Community engagement	Collaboration with or formation of village health committees and/or collaboration with local leaders
	Formation and/or support of women's groups
	Sharing locally obtained health–related data with the community
	Participatory Rural Appraisal (PRA)
	Formation and/or support of microcredit programs for women
	Involvement of older family members (men and grandparents/mothers–in–law)
Education of community–level staff, volunteers, beneficiaries and community members in general	Social marketing (media campaigns, posters, radio, etc.)
	Skits, stories and games for health education messages
	Peer–to–peer education (volunteer mothers visiting neighbors with targeted health messages)
	Education of grandmothers
	Positive deviance inquiry
	Training of trainers/cascade training
Health systems strengthening	Identification of cases of childhood illness in need of referral
	Strengthening referral system
	Strengthening of quality of care at referral facility
	Strengthening of supervisory system
	Strengthening logistics/drug supply system
	Training of providers at primary health center
	Training of community–level health care providers
Use of community health workers	Intermittent use of minimally trained volunteers for highly specific, targeted activities
	Use of volunteers for regular ongoing activities
	Use of trained and paid workers with 1–11 months of training
	Use of trained and paid workers with 1 year of training
Intervention delivery	Community case management
	Home visits
	Participatory women's groups
	Provision of health services at community outreach points by mobile teams from peripheral facilities

tional status as determined by anthropometry. Oftentimes, community members served as interviewers or collaborators for these surveys. In some projects, Participatory Rural Appraisal (PRA), an approach that incorporates the viewpoints of local people in the planning and management of development projects, was used to guide project planning or evaluation.

Various approaches were used to determine the beneficiary population (usually mothers, including pregnant women, and their young children) such as household censuses carried out by the project in collaboration with community members or the development of village rosters of beneficiaries. Sometimes projects included a disease–surveillance component using information provided by community–based workers and communities. Examples are surveillance for acute flaccid paralysis (to identify possible cases of polio) and for other vaccine–preventable diseases such as neonatal tetanus and measles. Some projects measured changes in mortality directly, either through prospective vital events registration as in Care Group projects [12] and in the pioneering CBPHC field project at Gadchiroli, India, conducted by SEARCH [13,14] or through retrospective measurements obtained from maternal birth histories [15,16]. Verbal autopsy methods have been used to assess the leading causes of child deaths in the project area and whether or not the cause of death "structure" has changed over time [17]. Finally, communities have been consulted during the project planning phase as well as at the time of project evaluation. In these circumstances, community members assist with data collection for structured surveys and participate as key informants or participants in focus group discussions.

Strategies for community engagement

Community engagement takes many forms and is commonly mentioned in the assessments included in our database (**Table 1**). Village health committees are often formed if they were not previously in existence, and projects work with them in project design, implementation and evaluation. Community leaders, including local religious leaders, are commonly consulted. Communities are often mobilized to participate in health campaigns or to practice key healthy behaviors. Many projects have worked with existing community groups or formed new ones, often women's groups. Activities that empower women are common forms of community engagement, including education and consciousness raising of women as well as formation and support of women's microcredit and savings groups.

Communities are commonly requested to participate in the selection of CHWs and to provide support to them and participate in their supervision. Finally, in some projects, special activities are geared toward engaging fathers, mothers–in–law, traditional healers and local drug sellers. Finally, though not commonly, projects have engaged communities by sharing surveillance and evaluation results. Noteworthy examples of projects with strong community engagement strategies include mobilization of churches in Mozambique [12] and Nigeria [18] and national mobilization of communities and short–term community workers for national health weeks in Sierra Leone [19].

Strategies for education of community–level staff, volunteers, beneficiaries and community members in general

Assessments of the effectiveness of projects included in our database have adopted many innovative approaches to educating CHWs, beneficiaries, and community members as a whole. Some have used social marketing channels such as radio and posters to convey key messages to the entire community. Others have conveyed health education messages through skits, puppet shows and games that engaged children, mothers, or the entire community. One noteworthy example of this approach is the World Relief child survival project in Cambodia [20,21].

Other approaches involved teaching health education messages to volunteer or paid community workers (who most often are mothers) who then conveyed them to their neighbors at the time of home visits or at meetings of small groups of neighbors. Sometimes projects targeted grandmothers for health education messages since they are respected and influential elders in the community. One particularly innovative educational strategy used in some projects is positive deviance inquiry, usually for addressing childhood undernutrition [22]. With this strategy, mothers of undernourished children in a village learn from the mothers of well–nourished children in the village how they care for their children – not just how they feed them but how they care for them more broadly.

Another approach used by some projects is called Care Groups [23], which involves training a small number of master trainers in a project area with a set of health education messages. These trainers each then train another set of trainers who then train another set. Through this "cascade training" approach, large numbers of peer–to–peer counselors can be trained to convey key messages to every household.

Strategies for health systems strengthening

Many CBPHC projects carried out health system strengthening activities of various sorts. One of the most common was providing mothers and their families with educational messages about warning signs for serious childhood illness or about pregnancy and childbirth for which care should be sought at a health facility. A stronger health system is one in which people seek care appropriately and, when potentially serious conditions are present, prompt care is sought. This is core feature of the approach known as Community–based Integrated Management of Childhood Illness (C–IMCI), utilized in many child survival projects funded by the US Agency for International Development, often with marked expansions of geographic coverage of key child survival interventions. A publication highlighting a number of these projects has been published [24].

Another approach has been to work with communities to establish emergency transport systems to ensure that mothers and children can access the nearest health facility whenever a complication arises and also ensure that the family can obtain transport at a fixed, fair, and affordable price. These referral systems are sometimes linked to insurance schemes whereby families pay small amounts of money on a regular basis, usually during pregnancy, to cover all or most of the cost of such transport if needed. One such approach has been developed by Curamericas for isolated mountainous communities in Guatemala [25,26].

Many projects, while implementing community–based interventions, also engage in activities to strengthen the quality of care provided at primary health care centers or referral hospitals, including the capacity of facilities to accept and care for referrals. This often takes the form of training staff who work there or helping the facility to improve its own stock of drugs and supplies.

Other approaches include improving the quality of the community–based health system itself by providing training to CHWs, by strengthening the supervision provided to CHWs, or strengthening the logistics/drug supply system for CHWs.

Strategies for use of community health workers

Community–based programs often rely on various types of CHWs – trained volunteers or more formally trained and paid workers who can implement specific interventions aimed at improving MNCH. The projects in our database engaged a broad variety of CHWs. For some projects, the training lasted only a few hours or days while for others CHWs had one year or more of full–time formal training. Some CHWs received only a "per diem" payment for attending a training course or a certificate for their service, while others were formally paid government employees. Some CHWs were volunteers or workers who had been engaged for a specific local project or study while others were part of a national government–run program.

Table 2 provides a listing and description of the types of CHWs described by reports in our database.

Strategies for implementation of interventions

Four types of strategies for implementing interventions were: (1) recognition, referral, and (in certain circumstances) treatment of serious childhood illness by mothers and/or CHWs; (2) routine systematic visitation of all homes, (3) facilitator–led participatory women's groups; and (4) provision of health services at community outreach points by mobile teams from peripheral facilities.

Community case management: recognition, referral, and (when possible) treatment of serious childhood illness by mothers and/or trained community agents

The review identified considerable evidence regarding the effectiveness of training and supervising CHWs to teach pregnant women and their families about danger signs during pregnancy and childbirth, during the newborn period, and among sick children [27–29]. CHWs can learn to recognize danger signs and they can teach these to mothers, other caregivers, and family members.

Some projects that were effective in improving neonatal and child health also trained and supported CHWs to manage these conditions themselves (or in some cases these CHWs also taught mothers how to treat these conditions). This requires, in addition to proper training, appropriate supervision and logistical support for medications and other supplies [30–33]. The community–based treatment modalities included administration of oral (and in a few cases intramuscular) antibiotics [34], administration of oral rehydration fluids, provision of highly nutritious foods available locally or commercially prepared (known as ready–to–use therapeutic foods, or RUTF), and in some cases provision of micronutrients such as iron, vitamin A and zinc. When community–level workers did not have the capacity to treat children with acute

Table 2. Specific examples of community health workers (CHWs) utilized in community–based primary health care (CBPHC) projects with evidence of effectiveness in improving neonatal and child health

Category of CHW	Names given to CHWs in this category	Comment
Intermittent use of minimally trained unsalaried workers for highly specific, targeted activities	Child Health Day volunteer	May receive a per diem payment
Use of unsalaried workers for regular ongoing activities	Promoters, peer educators, malaria or nutrition agents, Care Group volunteers, animators, community case management workers, nutrition counselor mothers, bridge–to–health teams, family health workers, community surveillance volunteers, female community health volunteers	May receive certain incentives such as uniforms, per diem payment for training, or an occasional small stipend
Use of workers with 1–11 months of training who receive a salary	Health agents, community health agents, family planning agents, health surveillance assistants, *accompagnateurs,* lead mothers, *soccoristas,* Care Group facilitators (animators or promoters)	
Use of workers with 1 year or more of training who are salaried	Auxiliary nurses, community health officers, health extension workers	

illness, they informed mothers and caretakers that urgent treatment at a referral health facility was needed. A comprehensive manual for community–based diagnosis and treatment of serious childhood illness is available for general use [35]. Integrated community case management (iCCM) for childhood illness is now being scaled up in many countries [36].

Routine systematic visitation of homes

Routine systematic visitation of homes makes it possible to identify those in need of basic services and to provide everyone in the program population with essential health education and selected key services, particularly during pregnancy and the early neonatal period. Community–level workers who make home visits are generally able to identify pregnant women and mothers of young children, provide education to them and other family members (especially husbands and mothers–in–law), recognize danger signs during pregnancy and childhood illness, encourage referral when danger signs are present, and provide treatment for certain conditions that can be identified at the time of home visits such as growth faltering, diarrhea, pneumonia, and malaria.

Based on current evidence, the World Health Organization and UNICEF recommend that all pregnant women receive two home visits during the prenatal period, one home visit during the first 24 hours after birth, and at least one visit as soon as possible after delivery [37]. Activities that should take place during these visits include the following: education about proper nutrition, promotion of antenatal care, education about danger signs during pregnancy and childbirth, promotion of breastfeeding immediately after birth, prevention of hypothermia, and measurement of the weight of newborns to identify low–birth–weight newborns who need additional home visits. A number of studies have highlighted the difficulties many women face in accessing health facilities due to distance and cost [38]. Home visitation provides an alternative for those without ready access to health facilities.

Home visitation is also an effective means of providing counseling about breastfeeding and appropriate complementary feeding, hand washing, prevention and treatment of diarrhea, detection and treatment of childhood pneumonia, and family planning services. There are a number of variations of home visitation strategies using community–level workers, from weekly home visits for providing micronutrients to children [39] to regular monthly visitation of all homes in a program population as part of a more comprehensive approach to delivering basic services to the entire population [40].

Finally, an ongoing program of home visitation provides a foundation of trust and awareness. When children develop signs of serious illness that can be managed by CHWs (such as for pneumonia, diarrhea or malaria), families will be more predisposed to contact the CHW for early and prompt treatment.

Participatory women's groups

Participatory women's groups are led by facilitators with less than two weeks of training who provide the opportunity for further empowerment and education about healthy behaviors, danger signs of serious illness, and proper care of the newborn. These groups may also address issues outside of the health domain that are a priority to the community and that may also have an indirect effect on health (such as income generation activities). These groups may also provide a vehicle for counseling about breastfeeding, birth spacing, infant feeding, hand washing, prevention and treatment of diarrhea, signs of childhood pneumonia, and danger signs during pregnancy and childbirth. Participatory women's groups also can be effective for assisting mothers to rehabilitate malnourished children detected through growth monitoring.

The literature illustrates several effective approaches to facilitating participatory women's groups, including the use of a participatory action–learning cycle [41,42], formation of Care Groups (10–15 women volunteers who meet with a facilitator (promoter/animator) once a month to learn a key health education message to disseminate to each of the mothers in the 10–15 households surrounding each volunteer) [43,44], and education sessions led by community mobilizers [45].

Provision of services at satellite clinics, including holding outreach immunization sessions, by mobile teams from peripheral facilities

Provision of services at satellite clinics, including holding outreach immunization sessions, by mobile teams based at health centers is a common means of community–based outreach. These mobile teams may have a vehicle or more likely a motorcycle, bicycle, horse or donkey, or they may even travel by foot. The provision of immunization services by mobile health teams at points beyond a peripheral health fa-

cility is now well–developed in many low–income countries [46]. Other examples of services that can be provided through outreach include promotion of and provision of family planning services, basic antenatal care, testing for HIV and syphilis, distribution of insecticide–treated bed nets, distribution of medications to prevent or treat malaria, and growth monitoring to detect cases of childhood malnutrition.

One widely implemented variation of this strategy is Child Health Days (or sometimes called Child Health Weeks). Generally occurring twice a year, they usually include some combination of immunization administration, vitamin A supplementation, nutritional monitoring (and referral of malnourished children), and distribution of oral rehydration packets, water–purification tablets, or de–worming tablets [47,48]. Services are provided at peripheral outreach points separate from a health center such as at a school or community building or even under a tree, and home visits are often carried out in addition to reach those mothers and children who did not come to the outreach points. These children are often identified on the basis of previously developed household registers.

Table 3 demonstrates which evidence–based child survival interventions can be implemented by which implementation modality. The interventions shown in **Table 3** are those which have been identified by the Lives Saved Tool (LiST) for inclusion in program plans for reducing under–5 mortality [49]. A more detailed discussion of these four intervention delivery strategies has been reported elsewhere [50].

Frequency of selected program–related processes

When program assessments that qualified for the review underwent data extraction, reviewers were asked to describe the degree to which communities were involved in various aspects of the project. Some of the findings are contained in **Table 4**. These findings demonstrate a high degree of community engagement, both in the maternal as well as the neonatal/child health CBPHC projects. More than three–fourths of the

Table 3. Child health interventions with strong evidence of effectiveness through community–based implementation

Technical intervention	Community–based intervention delivery strategy			
	Community case management	Home visits	Participatory women's groups	Outreach services
Immunizations: BCG, polio, diphtheria, pertussis, tetanus, measles, Haemophilus Influenza Type b (Hib), pneumococcus, rotavirus immunizations for children; tetanus immunization for mothers and women of reproductive age		X		X
Provision of supplemental vitamin A to children 6–59 months of age and to post–partum mothers		X		X
Provision of preventive zinc supplements to all children 6–59 months of age		X		X
Promotion of breastfeeding immediately after birth, exclusive breastfeeding during the first 6 months of life and continued non–exclusive breastfeeding beyond 6 months	X	X	X	X
Promotion of appropriate complementary feeding beginning at 6 months of age	X	X	X	X
Promotion of hygiene (including hand washing), safe water, and sanitation	X	X	X	X
Promotion of oral rehydration therapy (ORT) for diarrhea with or without zinc supplementation	X	X	X	X
Promotion of clean deliveries, especially where most births occur at home and hygiene is poor		X	X	X
Detection/referral of pneumonia with or without provision of community–based treatment	X	X	X	X
Home–based neonatal care (frequent home visits for promotion of immediate and exclusive breastfeeding, promotion of cleanliness, prevention of hypothermia, and diagnosis and treatment of neonatal sepsis by CHW)	X	X	X	
Community–based rehabilitation of children with protein–calorie undernutrition through food supplementation (including rehabilitation of children with severe acute undernutrition through ready–to–use dry therapeutic foods)	X	X	X	X
Insecticide–treated bed nets (ITNs) in malaria–endemic areas		X	X	X
Indoor residual spraying in malaria–endemic areas		X		X
Detection/referral of malaria with or without provision of community–based treatment	X	X	X	X
Intermittent preventive treatment of malaria during pregnancy (IPTp) and infancy (IPTi) in malaria–endemic areas		X		X
Detection and treatment of syphilis in pregnant women in areas of high prevalence		X		X
Promotion of HIV testing in pregnant women and prevention of mother–to–child transmission (PMTCT) of HIV infection	X	X	X	X
Iodine supplementation in iodine–deficient areas where fortified salt is not consumed		X	X	X
Provision and promotion of family planning services		X	X	X

*Outreach of health facility staff includes holding mobile clinics and/or immunization sessions at specified locations outside of health facilities in outlying communities on a regular basis.

Table 4. Community involvement in the implementation of maternal, neonatal and child health CBPHC projects included in the database

Stage of implementation	Activity	Percentage of assessments of maternal CBPHC projects that describe activity (N = 152)	Percentage of assessments of neonatal and/or child health CBPHC projects that describe activity (N = 548)	Percentage of assessments of all maternal, neonatal and/or child health CBPHC projects combined that describe activity (N = 700)
Inputs	Training of CHWs	86.3	74.0	76.6
	Formation and/or support of community groups	53.6	35.5	39.5
	Community involvement in planning	46.4	36.1	38.3
Processes	Community involvement in implementation	90.8	78.1	80.9
	Promotion of partnerships between the community and the health program	73.2	53.6	57.8
	Promotion of the use of local resources	74.5	53.2	57.8
	Promotion of community empowerment	62.7	53.6	55.6
	Promotion of leadership in the community	41.8	30.4	32.9
	Promotion of women's empowerment	62.7	40.6	45.4
	Promotion of equity	24.8	24.8	24.8
Evaluation	Community involvement in evaluation	50.3	37.5	40.3

projects trained CHWs and more than one–third engaged communities in the formation or support of community groups as well as in the planning of project activities. 81% of the projects engaged communities in project implementation, and more than half promoted partnerships between the community and the health program, promoted the use of local resources, or promoted community empowerment. Almost half promoted women's empowerment, one–third promoted leadership in the community, and one–quarter promoted equity. 40% of the projects involved the community in the project evaluation. These findings are highly likely to underestimate the true situation since a large portion of the assessments did not go into this level of detail in describing the community engagement component of the project. Information provided in the assessment was rarely sufficient to provide any deeper understanding of the quality of community engagement or details of how community engagement was actually carried out.

DISCUSSION

This analysis of strategies used by effective community–based programs for improving MNCH has documented a high degree of community engagement in project implementation. Six categories of strategies were identified: (a) program design and evaluation, (b) community collaboration, (c) education for community–level staff, volunteers, beneficiaries and community members, (d) health systems strengthening, (e) use of CHWs, and (f) intervention delivery. Within each strategy category, community engagement was an essential element for strategy implementation. By its very nature, CPBHC requires community engagement for virtually all aspects of programming. Each of these aspects of community engagement are part of the process of building capacity within the community for the benefit of the health program and its capacity to improve the health of mothers, neonates and children. Further elaboration of these strategies as they pertain specifically to maternal, neonatal and child health are discussed in other articles in this series [51–53].

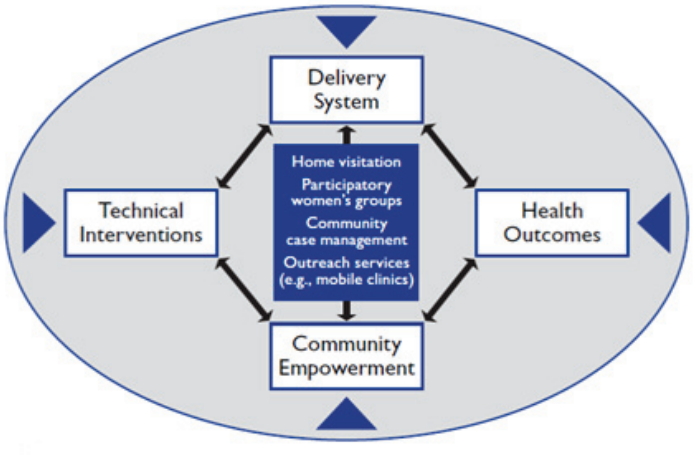

Figure 1. A conceptual framework for planning, implementing and evaluating community–based primary health care programs for improving maternal, neonatal and child health. Blue triangles represent contextual factors.

In general, the details of community–based strategies and approaches used by projects to improve MNCH have not been well described in the peer–reviewed scientific literature, where the focus is usually on the health impact of the intervention, or set of interventions, rather than on describing in sufficient detail the exact implementation strategies used to achieve that impact. The findings of this review provide insights into the richness of this dimension of implementation strategies and its importance for program effectiveness. **Figure 1**

contains a framework that attempts to capture the importance of community empowerment for improving the health of mothers, neonates and children. The delivery process, along with the technical content of the interventions, is embedded in the eventual health outcomes produced together by the health system working with the community.

The framework in **Figure 1** and in fact the strategies identified in this article as well as the interventions identified in other articles in this series all highlight the importance of community engagement and community–based delivery of interventions outside of health facilities in order to reach those who need services. As Gwatkin et al. observed in their 1980 comprehensive review of the effectiveness of programs improving child health and nutrition [54]:

"*Unless services reach those in need, even the best–conceived primary health and nutrition care programs can obviously have little impact on mortality. Thus, … the development of plans for getting services to the people is as important as are decisions concerning which services should be offered.*"

CBPHC involves, above all, getting services to those who need them.

Figure 1 emphasizes the importance of context. In fact, strategies in general are context– specific. In order for community–based programs to be successful, the context must be carefully considered in order to select the most appropriate combinations of interventions and implementation strategies. Program effectiveness in improving MNCH in a given geographical area requires knowing the local epidemiological priorities (ie, the most frequent and readily preventable or treatable serious conditions) as well as the feasibility of achieving high coverage of evidence–based interventions targeting the epidemiological priorities given the available resources, logistical challenges, contextual constraints (including health system constraints), and available implementation strategies.

The assessments making up our database are derived largely from small demonstration projects, short–term trials, and efficacy studies of one or a small number of interventions. More independent, rigorous assessments of large–scale integrated programs at scale carried out for five or more years are needed. There are few examples of rigorous assessments of CBPHC at scale over a longer time period. However, these few studies show that the bottlenecks to the effectiveness of large–scale programs include assuring that the number of CHWs and their supervisors is sufficient for the population being served, and that CHWs receive adequate support and supervision, including the basic commodities they need to do their work [55,56]. Future research is needed to rigorously assess the effectiveness of community–based approaches at scale in relatively routine conditions [57].

Elsewhere in this series we review the common characteristics of four projects that have long–term evidence of effectiveness [58]. A more in–depth analysis of the strategies and effectiveness of the larger projects included in our review has not been carried out. Although such an analysis would be useful, unfortunately it is beyond the scope of the current series of articles. Questions that might be addressed through such an analysis include:

- Is effectiveness weakened as projects scale up? If not, what specific steps were taken to maintain quality and effectiveness?
- What kinds of community engagement and what kinds of community–level workers were used in different projects, and how did these features contribute to effectiveness?
- What is the contribution of civil society and NGOs to larger–scale projects and how do these contributions affect the effectiveness of public–sector programs?

Health programs need to ensure that local health facilities are appropriately staffed and that the staff has the training, equipment, supplies and transport needed to support community–level work. For example, mobile health teams based at peripheral facilities need, at a minimum, steady supplies of vaccines and adequate transport. Additionally, compassionate and high–quality curative and referral care, including basic hospital and surgical care, lends credibility to the community–based work and the workers who provide it. Small, well–run first–level referral hospitals can be cost–effective in improving health and can serve as an important asset for the community to gain trust in the health system [59,60].

Health systems can benefit greatly from having a community–level worker implement evidence–based interventions in order to achieve high population coverage of these interventions. One recent analysis [61] concluded that almost two–thirds (59%) of maternal, prenatal, neonatal, and child deaths that could be prevented by all currently available interventions could be prevented with community–based approaches. Facility–based approaches would avert far fewer (20% at primary health care centers and 22% at hospitals).

Of course, the community–level workers who implement these interventions in collaboration with communities must be appropriately trained and supported; a recent Cochrane Review identified the need for adequate and standardized compensation or incentives for CHWs [62]. An effective strategy must be developed for promptly selecting and training new CHWs to replace those who are no longer functioning in this capacity. Although these decisions are normally made by program leaders in consultation with local communities, examples exist in which communities have taken full responsibility for this process [63]. In addition to continuing research on the capability of CHWs to provide specific interventions, more research will be needed on how many interventions a given CHW can take on and what training and supervision are required to maintain quality.

As we have seen in this analysis, empowering the community to be a partner with the health system can help strengthen community–based delivery strategies, as described in **Figure 1**. The finding supports the recent assertion of Marston et al. [64] that community participation (in which communities work together with health services for the co–production of health care) will be central for achieving the recently released World Health Organization global strategy for women's and children's health [65].

Community case management, routine systematic home visitation, participatory women's groups, and outreach services provided by mobile teams represent important delivery strategies for improving MNCH in high–mortality, resource–constrained settings. These strategies are not the only approaches to implementing interventions that can improve child health, but they are the most common strategies used in the projects whose assessments are included in our database.

Routine systematic home visitation has the unique advantage of not only delivering key interventions to all who need them but also of ensuring that no one is left out. Marginalization and discrimination of sub–groups in high–mortality, resource–constrained settings are not uncommon, leading to many social barriers – in addition to geographic barriers – in accessing services at facilities or even at peripheral outreach points. Thus, for instance, home visits have proven to be an essential strategy for the final stages of polio eradication [66].

Cesar Victora, one of the widely acknowledged leaders of the global movement to improve MNCH, lamented that "We have the bullets [interventions] but not the guns [implementation strategies]" for a second child survival revolution [67]. The analysis provided here helps to point the way forward by identifying implementation strategies used by programs with demonstrated effectiveness.

Study limitations

The word limits placed on peer–reviewed journal articles make it difficult to fully describe implementation strategies. Our data extraction process was set up to glean whatever information was available regarding these strategies. Our database has been strengthened by the inclusion of 116 assessments that are not peer–reviewed journal articles, and many of them describe their strategies in greater detail. Most of these additional 116 assessments are either unpublished evaluation reports that are publicly available or books. These documents are useful in part because they are not subject to the same space limitations as peer–reviewed articles and can provide more information. Further consolidation and analysis of the extensive and rich evidence about strategies for implementation of CBPHC projects described in the gray literature (including a rigorous examination of the quality of the assessments) would be useful but goes beyond the capacity of the current series of articles to address.

Another limitation of this study is that some of the findings reported here are based on subjective judgments of reviewers. However, the procedure we used – having each assessment reviewed independently by two researchers and then having a third resolve any differences – helps to mitigate this limitation.

A final limitation of our review is the overall difficulty of assessing community participation and engagement. While one of the strengths of our paper is highlighting and further describing the role of the community in implementing effective CBPHC projects, we also note that frameworks and indicators for assessing the quality and effectiveness of this critical dimension of CBPHC were rarely used in the assessments included in our review. Appropriate frameworks and indicators need to be used by future CBPHC projects so that they can more fully describe the role of the community in the process of implementation and better assess the contribution that this made to health outcomes. Useful and more robust approaches to describing and analyzing the process of community participation are available [68,69].

CONCLUSIONS

This analysis provides an overview of the ways in which CBPHC projects have planned and evaluated their activities, how they collaborated with communities, how they have used CHWs, and how they have strengthened health systems. The evidence from this review supports the proposition that the application of these strategies can accelerate the decline in maternal, neonatal and child mortality in priority countries. These strategies require that the health system establish functional partnerships with community leaders and community members in order to achieve high levels of coverage of evidence–based interventions. Building the capacity of health systems to work with communities to implement these strategies is one of the priority tasks for ending preventable child and maternal deaths by 2030.

Using the strategies identified here for strengthening CBPHC to improve MNCH can establish an entry point for developing synergies with community–based approaches for the detection and treatment of HIV/AIDS [70], tuberculosis [71] and malaria [31] as well as for the promotion of family planning services [72], detection and treatment of adult non–communicable diseases [73], and the achievement of universal health coverage. This review supports the growing recognition that community–based programs in high–mortality, resource–constrained settings have a great potential for improving MNCH at low cost.

Nonetheless, awareness about the full potential of CBPHC is still not yet widespread, and evidence of the effectiveness of CBPHC at scale in priority settings remains limited. Determining the fit and feasibility, within existing local and health systems constraints, of CBPHC implementation strategies for MNCH interventions is a pressing challenge for national programs. Unleashing the full potential of communities as partners in the process of building effective health systems in high–mortality, resource–constrained settings is one of the great frontiers for global health in the 21st century.

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1 World Health Organization, Organisation for Economic Co-operation and Development, World Bank. Effective Aid, Better Health. Geneva: World Health Organization, 2008.

2 Reich MR, Takemi K. G8 and strengthening of health systems: follow-up to the Toyako summit. Lancet. 2009;373:508-15. Medline:19150128 doi:10.1016/S0140-6736(08)61899-1

3 Bhutta ZA, Ali S, Cousens S, Ali TM, Haider BA, Rizvi A, et al. Alma-Ata: Rebirth and revision 6–interventions to address maternal, newborn, and child survival: what difference can integrated primary health care strategies make? Lancet. 2008;372:972-89. Medline:18790320 doi:10.1016/S0140-6736(08)61407-5

4 Ekman B, Pathmanathan I, Liljestrand J. Integrating health interventions for women, newborn babies, and children: a framework for action. Lancet. 2008;372:990-1000. Medline:18790321 doi:10.1016/S0140-6736(08)61408-7

5 Rosato M, Laverack G, Grabman LH, Tripathy P, Nair N, Mwansambo C, et al. Community participation: lessons for maternal, newborn, and child health. Lancet. 2008;372:962-71. Medline:18790319 doi:10.1016/S0140-6736(08)61406-3

6 Hill Z, Kirkwood B, Edmond KM. Family and community practices that promote child survival, growth and development: a review of the evidence. Geneva, Switzerland: World Health Organization; 2004.

7 Bhutta ZA, Darmstadt GL, Hasan BS, Haws RA. Community-based interventions for improving perinatal and neonatal health outcomes in developing countries: a review of the evidence. Pediatrics. 2005;115:519-617. Medline:15866863 doi:10.1542/peds.2004-1441

8 Darmstadt GL, Bhutta ZA, Cousens S, Adam T, Walker N, de Bernis L. Evidence-based, cost-effective interventions: how many newborn babies can we save? Lancet. 2005;365:977-88. Medline:15767001 doi:10.1016/S0140-6736(05)71088-6

9 Bhutta ZA, Ahmed T, Black RE, Cousens S, Dewey K, Giugliani E, et al. What works? Interventions for maternal and child undernutrition and survival. Lancet. 2008;371:417-40. Medline:18206226 doi:10.1016/S0140-6736(07)61693-6

10 Jones G, Steketee RW, Black RE, Bhutta ZA, Morris SS. How many child deaths can we prevent this year? Lancet. 2003;362:65-71. Medline:12853204 doi:10.1016/S0140-6736(03)13811-1

11 Perry H, Rassekh B, Gupta S, Wilhelm J, Freeman P. A comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 1. rationale, methods and database description. J Glob Health. 2017;7:010901.

12 Edward A, Ernst P, Taylor C, Becker S, Mazive E, Perry H. Examining the evidence of under-five mortality reduction in a community-based programme in Gaza, Mozambique. Trans R Soc Trop Med Hyg. 2007;101:814-22. Medline:17482222 doi:10.1016/j.trstmh.2007.02.025

13 Bang AT, Bang RA, Tale O, Sontakke P, Solanki J, Wargantiwar R, et al. Reduction in pneumonia mortality and total childhood mortality by means of community-based intervention trial in Gadchiroli, India. Lancet. 1990;336:201-6. Medline:1973770 doi:10.1016/0140-6736(90)91733-Q

14 Bang AT, Bang RA, Reddy HM. Home-based neonatal care: summary and applications of the field trial in rural Gadchiroli, India (1993 to 2003). J Perinatol. 2005;25 Suppl 1:S108-22. Medline:15791272 doi:10.1038/sj.jp.7211278

15 Perry H, Berggren W, Berggren G, Dowell D, Menager H, Bottex E, et al. Long-term reductions in mortality among children under age 5 in rural Haiti: effects of a comprehensive health system in an impoverished setting. Am J Public Health. 2007;97:240-6. Medline:17194853 doi:10.2105/AJPH.2006.088732

16 Johnson AD, Thomson DR, Atwood S, Alley I, Beckerman JL, Kone I, et al. Assessing early access to care and child survival during a health system strengthening intervention in Mali: a repeated cross sectional survey. PLoS One. 2013;8:e81304. Medline:24349053 doi:10.1371/journal.pone.0081304

17 Perry HB, Shanklin DS, Schroeder DG. Impact of a community-based comprehensive primary healthcare programme on infant and child mortality in Bolivia. J Health Popul Nutr. 2003;21:383-95. Medline:15038594

18 Ezeanolue EE, Obiefune MC, Ezeanolue CO, Ehiri JE, Osuji A, Ogidi AG, et al. Effect of a congregation-based intervention on uptake of HIV testing and linkage to care in pregnant women in Nigeria (Baby Shower): a cluster randomised trial. Lancet Glob Health. 2015;3:e692-700. Medline:26475016 doi:10.1016/S2214-109X(15)00195-3

19 Sesay FF, Hodges MH, Kamara HI, Turay M, Wolfe A, Samba TT, et al. High coverage of vitamin A supplementation and measles vaccination during an integrated Maternal and Child Health Week in Sierra Leone. Int Health. 2015;7:26-31. Medline:25316706 doi:10.1093/inthealth/ihu073

20 Relief W. "Light for Life" Child Survival Project, Kampong Cam Province (Cambodia): Final Evaluation (2003-2007). Baltimore, MD: World Relief, 2007.

21 Perry H, Sivan O, Bowman G, Casazza L, Edward A, Hansen K, et al. Averting childhood deaths in resource-constrained settings through engagement with the community: an example from Cambodia. In: Gofin J, Gofin R, editors. Essentials of Community Health. Sudbury, MA: Jones and Bartlett; 2010.

22 Berggren G. Nutritional Education and rehabilitation Program: A Save the Children Project in Vietnam. In: Wollinka O, Keeley E, Burkhalter RB, Bashir N, editors. The Hearth Nutrition Model: Applications in Haiti, Vietnam, and Bangladesh. Wheaton, Il, and Arlington, VA: World Relief and BASICS; 1997.

23 Perry H, Morrow M, Borger S, Weiss J, DeCoster M, Davis T, et al. Care Groups I: An innovative community-based strategy for improving maternal, neonatal, and child health in resource-constrained settings. Glob Health Sci Pract. 2015;3:358-69. Medline:26374798 doi:10.9745/GHSP-D-15-00051

24 Ricca J, Kureshy N, Leban K, Prosnitz D, Ryan L. Community-based intervention packages facilitated by NGOs demonstrate plausible evidence for child mortality impact. Health Policy Plan. 2014;29:204-16. Medline:23434515 doi:10.1093/heapol/czt005

25 Global C. Focused Strategic Assessment: USAID Child Survival and Health Grants Program "Community-Based, Impact-Oriented Child Survival in Huehuetenango, Guatemala". 2015. Available: http://www.mcsprogram.org/wp-content/uploads/2016/09/Curamericas_Guatemala_FE.pdf. Accessed: 26 April 2017.

26 Stollak I, Valdez M, Rivas K, Perry H. Casas Maternas in the Rural Highlands of Guatemala: a mixed-methods case study of the introduction and utilization of birthing facilities by an indigenous population. Glob Health Sci Pract. 2016;4:114-31. Medline:27016548 doi:10.9745/GHSP-D-15-00266

27 Bang AT, Reddy HM, Deshmukh MD, Baitule SB, Bang RA. Neonatal and infant mortality in the ten years (1993 to 2003) of the Gadchiroli field trial: effect of home-based neonatal care. J Perinatol. 2005;25 Suppl 1:S92-107. Medline:15791283 doi:10.1038/sj.jp.7211277

28 Baqui AH, El-Arifeen S, Darmstadt GL, Ahmed S, Williams EK, Seraji HR, et al. Effect of community-based newborn-care intervention package implemented through two service-delivery strategies in Sylhet district, Bangladesh: a cluster-randomised controlled trial. Lancet. 2008;371:1936-44. Medline:18539225 doi:10.1016/S0140-6736(08)60835-1

29 Kumar V, Mohanty S, Kumar A, Misra RP, Santosham M, Awasthi S, et al. Effect of community-based behaviour change management on neonatal mortality in Shivgarh, Uttar Pradesh, India: a cluster-randomised controlled trial. Lancet. 2008;372:1151-62. Medline:18926277 doi:10.1016/S0140-6736(08)61483-X

30 Baqui AH, Arifeen SE, Williams EK, Ahmed S, Mannan I, Rahman SM, et al. Effectiveness of home-based management of newborn infections by community health workers in rural Bangladesh. Pediatr Infect Dis J. 2009;28:304-10. Medline:19289979 doi:10.1097/INF.0b013e31819069e8

31 Kidane G, Morrow RH. Teaching mothers to provide home treatment of malaria in Tigray, Ethiopia: a randomised trial. Lancet. 2000;356:550-5. Medline:10950232 doi:10.1016/S0140-6736(00)02580-0

32 Sazawal S, Black RE. Effect of pneumonia case management on mortality in neonates, infants, and preschool children: a meta-analysis of community-based trials. Lancet Infect Dis. 2003;3:547-56. Medline:12954560 doi:10.1016/S1473-3099(03)00737-0

33 Chowdhury AMR, Cash RA. A Simple Solution: Teaching Millions to Treat Diarrhoea at Home. Dhaka, Bangladesh: University Press Limited; 1996.

34 Coffey PS, Sharma J, Gargi KC, Neupane D, Dawson P, Pradhan YV. Feasibility and acceptability of gentamicin in the Uniject prefilled injection system for community-based treatment of possible neonatal sepsis: the experience of female community health volunteers in Nepal. J Perinatol. 2012;32:959-65. Medline:22422117 doi:10.1038/jp.2012.20

35 CORE Group. Save the Children, BASICS. Community case management essentials: Treating common childhood illnesses in the community. A guide for program managers. Washington, DC: CORE Group; 2010. Available: http://www.coregroup.org/storage/documents/CCM/CCMbook-internet2.pdf. Accessed: 3 April 2017.

36 Young M, Wolfheim C, Marsh DR, Hammamy D. World Health Organization/United Nations Children's Fund Joint Statement on Integrated Community Case Management: an equity-focused strategy to improve access to essential treatment services for children. Am J Trop Med Hyg. 2012;87:6-10. Medline:23136272 doi:10.4269/ajtmh.2012.12-0221

37 WHO. UNICEF. WHO/UNICEF Joint Statement: Home Visits for the Newborn Child: A Strategy to Improve Survival. 2009. Available: http://apps.who.int/iris/bitstream/10665/70002/1/WHO_FCH_CAH_09.02_eng.pdf. Accessed: 26 April 2017.

38 Tanser F, Gijsbertsen B, Herbst K. Modelling and understanding primary health care accessibility and utilization in rural South Africa: an exploration using a geographical information system. Soc Sci Med. 2006;63:691-705. Medline:16574290 doi:10.1016/j.socscimed.2006.01.015

39 Baqui AH, Zaman K, Persson LA, El Arifeen S, Yunus M, Begum N, et al. Simultaneous weekly supplementation of iron and zinc is associated with lower morbidity due to diarrhea and acute lower respiratory infection in Bangladeshi infants. J Nutr. 2003;133:4150-7. Medline:14652364

40 Perry H, Cayemittes M, Philippe F, Dowell D, Dortonne JR, Menager H, et al. Reducing under-five mortality through Hopital Albert Schweitzer's integrated system in Haiti. Health Policy Plan. 2006;21:217-30. Medline:16565151 doi:10.1093/heapol/czl005

41 Prost A, Colbourn T, Seward N, Azad K, Coomarasamy A, Copas A, et al. Women's groups practising participatory learning and action to improve maternal and newborn health in low-resource settings: a systematic review and meta-analysis. Lancet. 2013;381:1736-46. Medline:23683640 doi:10.1016/S0140-6736(13)60685-6

42 Manandhar DS, Osrin D, Shrestha BP, Mesko N, Morrison J, Tumbahangphe KM, et al. Effect of a participatory intervention with women's groups on birth outcomes in Nepal: cluster-randomised controlled trial. Lancet. 2004;364:970-9. Medline:15364188 doi:10.1016/S0140-6736(04)17021-9

43 Perry H, Morrow M, Borger S, Weiss J, DeCoster M, Davis T, et al. Care Groups I: an emerging innovative community-based delivery strategy for improving maternal, neonatal and child health in high-mortality, resource-constrained settings. Glob Health Sci Pract. 2015;3:358-69. Medline:26374798 doi:10.9745/GHSP-D-15-00051

44 Perry H, Morrow M, Davis T, Borger S, Weiss J, DeCoster M, et al. Care Groups II: a summary of the maternal, neonatal and child health outcomes achieved in high-mortality, resource-constrained settings. Glob Health Sci Pract. 2015;3:370-81. Medline:26374799 doi:10.9745/GHSP-D-15-00052

45 Bhutta ZA, Memon ZA, Soofi S, Salat MS, Cousens S, Martines J. Implementing community-based perinatal care: results from a pilot study in rural Pakistan. Bull World Health Organ. 2008;86:452-9. Medline:18568274 doi:10.2471/BLT.07.045849

46 UNICEF. Tracking Progress in Maternal, Newborn and Child Survival. 2008. Available: http://www.who.int/pmnch/Countdownto2015FINALREPORT-apr7.pdf/. Accessed:26 April 2017.

47 Doherty T, Chopra M, Tomlinson M, Oliphant N, Nsibande D, Mason J. Moving from vertical to integrated child health programmes: experiences from a multi-country assessment of the Child Health Days approach in Africa. Trop Med Int Health. 2010;15:296-305. Medline:20070638 doi:10.1111/j.1365-3156.2009.02454.x

48 Palmer AC, Diaz T, Noordam AC, Dalmiya N. Evolution of the child health day strategy for the integrated delivery of child health and nutrition services. Food Nutr Bull. 2013;34:412-9. Medline:24605691 doi:10.1177/156482651303400406

49 Walker N, Tam Y, Friberg IK. Overview of the Lives Saved Tool (LiST). BMC Public Health. 2013;13 Suppl 3:S1. Medline:24564438 doi:10.1186/1471-2458-13-S3-S1

50 Perry H, Freeman P, Gupta S, Rassekh B. Building on the current evidence to strengthen community-based service delivery strategies for promoting child survival. 2010. Available: http://www.mchip.net/sites/default/files/USAID%20CBPHC%20FINAL.pdf. Accessed: 3 April 2017.

51 Jennings M, Pradhan S, Schleiff M, Sacks E, Freeman P, Gupta S, et al. Comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 2. maternal health findings. J Glob Health. 2017;7:010902.

52 Sacks E, Freeman P, Sakyi K, Jennings M, Rassekh B, Gupta S, et al. Comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 3. neonatal health findings. J Glob Health. 2017;7:010903.

53 Freeman P, Schleiff M, Sacks E, Rassekh B, Gupta S, Perry H. Comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 4. child health findings. J Glob Health. 2017;7:010904.

54 Gwatkin DR, Wilcox JR, Wray JD. Can health and nutrition interventions make a difference? Washington, DC: Overseas Development Council; 1980.

55 Bryce J, Gilroy K, Jones G, Hazel E, Black RE, Victora CG. The Accelerated Child Survival and Development programme in west Africa: a retrospective evaluation. Lancet. 2010;375:572-82. Medline:20071020 doi:10.1016/S0140-6736(09)62060-2

56 Azad K, Barnett S, Banerjee B, Shaha S, Khan K, Rego AR, et al. Effect of scaling up women's groups on birth outcomes in three rural districts in Bangladesh: a cluster-randomised controlled trial. Lancet. 2010;375:1193-202. Medline:20207412 doi:10.1016/S0140-6736(10)60142-0

57 Evaluation: the top priority for global health. Lancet. 2010;375:526.

58 Perry H, Rassekh B, Gupta S, Freeman P. Comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 7. shared characteristics of projects with evidence of long–term mortality impact. J Glob Health. 2017;7:010309.

59 McCord C, Chowdhury Q. A cost effective small hospital in Bangladesh: what it can mean for emergency obstetric care. Int J Gynaecol Obstet. 2003;81:83-92. Medline:12676406 doi:10.1016/S0020-7292(03)00072-9

60 Gosselin RA, Thind A, Bellardinelli A. Cost/DALY averted in a small hospital in Sierra Leone: what is the relative contribution of different services? World J Surg. 2006;30:505-11. Medline:16528459 doi:10.1007/s00268-005-0609-5

61 Black RE, Levin C, Walker N, Chou D, Liu L, Temmerman M, et al. Reproductive, maternal, newborn, and child health: key messages from Disease Control Priorities 3rd Edition. Lancet. 2016;388:2811-24.

62 Glenton C, Colvin CJ, Carlsen B, Swartz A, Lewin S, Noyes J, et al. Barriers and facilitators to the implementation of lay health worker programmes to improve access to maternal and child health: qualitative evidence synthesis. Cochrane Database Syst Rev. 2013;8:CD010414. Medline:24101553

63 Special Programme for Research and Training in Tropical Diseases. Community-directed Interventions for Major Health Problems in Africa: A Final Multi-Country Report. Geneva, Switzerland: World Health Organization, 2008.

64 Marston C, Hinton R, Kean S, Baral S, Ahuja A, Costello A, et al. Community participation for transformative action on women's, children's and adolescents' health. Bull World Health Organ. 2016;94:376-82. Medline:27152056 doi:10.2471/BLT.15.168492

65 WHO. The Global Strategy for Women's, Children's and Adolescents' Health (2016-2030): Survive, Thrive, Transform. 2016. Available: https://www.usaid.gov/sites/default/files/Final-AOTC-file-v2.pdf. Accessed: 3 April 2017.

66 Curry DW, Perry HB, Tirmizi SN, Goldstein AL, Lynch MC. Assessing the effectiveness of house-to-house visits on routine oral polio immunization completion and tracking of defaulters. J Health Popul Nutr. 2014;32:356-66. Medline:25076672

67 Victora C. Presentation. Global Forum for Health Research; Mexico City2004.

68 Rifkin SB, Muller F, Bichmann W. Primary health care: on measuring participation. Soc Sci Med. 1988;26:931-40. Medline:3388072 doi:10.1016/0277-9536(88)90413-3

69 Molyneux S, Atela M, Angwenyi V, Goodman C. Community accountability at peripheral health facilities: a review of the empirical literature and development of a conceptual framework. Health Policy Plan. 2012;27:541-54. Medline:22279082 doi:10.1093/heapol/czr083

70 Farmer P, Leandre F, Mukherjee JS, Claude M, Nevil P, Smith-Fawzi MC, et al. Community-based approaches to HIV treatment in resource-poor settings. Lancet. 2001;358:404-9. Medline:11502340 doi:10.1016/S0140-6736(01)05550-7

71 Chowdhury AM, Chowdhury S, Islam MN, Islam A, Vaughan JP. Control of tuberculosis by community health workers in Bangladesh. Lancet. 1997;350:169-72. Medline:9250184 doi:10.1016/S0140-6736(96)11311-8

72 Prata N, Vahidnia F, Potts M, Dries-Daffner I. Revisiting community-based distribution programs: are they still needed? Contraception. 2005;72:402-7. Medline:16307960 doi:10.1016/j.contraception.2005.06.059

73 Mishra SR, Neupane D, Preen D, Kallestrup P, Perry HB. Mitigation of non-communicable diseases in developing countries with community health workers. Global Health. 2015;11:43. Medline:26555199 doi:10.1186/s12992-015-0129-5

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Comprehensive review of the evidence regarding the effectiveness of community–based primary health care in improving maternal, neonatal and child health: 7. shared characteristics of projects with evidence of long–term mortality impact

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Background There is limited evidence about the long–term effectiveness of integrated community–based primary health care (CBPHC) in improving maternal, neonatal and child health. However, the interventions implemented and the approaches used by projects with such evidence can provide guidance for ending preventable child and maternal deaths by the year 2030.

Methods A database of 700 assessments of the effectiveness of CBPHC in improving maternal, neonatal and child health has been assembled, as described elsewhere in this series. A search was undertaken of these assessments of research studies, field project and programs (hereafter referred to as projects) with more than a single intervention that had evidence of mortality impact for a period of at least 10 years. Four projects qualified for this analysis: the Matlab Maternal Child Health and Family Planning (MCH–FP) Project in Bangladesh; the Hôpital Albert Schweitzer in Deschapelles, Haiti; the Comprehensive Rural Health Project (CRHP) in Jamkhed, India; and the Society for Education, Action and Research in Community Health (SEARCH) in Gadchiroli, India.

Results These four projects have all been operating for more than 30 years, and they all have demonstrated reductions in infant mortality, 1– to 4–year mortality, or under–5 mortality for at least 10 years. They share a number of characteristics. Among the most notable of these are: they provide comprehensive maternal, child health and family planning services, they have strong community–based programs that utilize community health workers who maintain regular contact with all households, they have develop strong collaborations with the communities they serve, and they all have strong referral capabilities and provide first–level hospital care.

Conclusions The shared features of these projects provide guidance for how health systems around the world might improve their effectiveness in improving maternal, neonatal and child health. Strengthening these features will contribute to achieving the goal of ending preventable child and maternal deaths by the year 2030.

Sustainability of effectiveness in improving maternal, neonatal and child health (MNCH) is an ideal that all MNCH programs seek. However, specially funded projects that undergo evaluation usually have a relatively short duration of five years or less. National demographic and health surveys may show long–term

national improvements in child health, but determining the programmatic factors responsible for those improvements is difficult. As we have seen in this series of articles, the evidence regarding the effectiveness of community–based primary health care (CBPHC) in improving MNCH is based primarily on short–term assessments of a smaller group of selected interventions. Although two–thirds (66.7%) of the 152 maternal health assessments in our review were of projects with more than five interventions, only 15.8% of the projects were assessed for five or more years. Three–fourths of the 548 assessments of neonatal/child health projects included in our review assessed four or fewer interventions that were implemented over a period of less than five years.

However, one important question this review can address is: *What packages of community–based primary health care activities have produced evidence of long–term impact on MNCH?* A related question is: *Are there any common implementation strategies that these programs have in common that might help to explain their long–term effectiveness?* The answers to such questions can be helpful in considering how CBPHC can most effectively improve the health of mothers, neonates and children at scale over the longer term in high–mortality, resource–constrained settings.

The purpose of the current paper is to review the database assembled for the current journal supplement, of which this article is a part, and to describe the features of projects with more than one intervention that have evidence of long–term impact on maternal, neonatal or child health.

METHODS

The database of assessments of the effectiveness of CBPHC in improving MNCH has been described elsewhere in this series [1]. In short, it consists of data extracted from 700 documents describing the effectiveness of one or more interventions that have been implemented in the community outside of a health facility. Each assessment consisted of measurements of changes in maternal, neonatal and child health in terms of changes in population coverage of one or more evidence–based child survival interventions, in nutritional status, in serious morbidity, or in mortality. We queried this database for programs/projects/studies (hereafter referred to as projects) that had a duration of 10 years or more. Three assessments in the maternal health database were identified, and none of these met the criteria for this analysis. Twenty–one assessments in the neonatal/child health database were identified. Of these, 14 did not meet the criteria for this study for the reasons shown in **Figure 1**.

As shown in **Table 1**, 17 assessments of projects having a duration of 10 years or more were excluded from this analysis primarily because no measure of changes in mortality were available or the project implemented only one intervention.

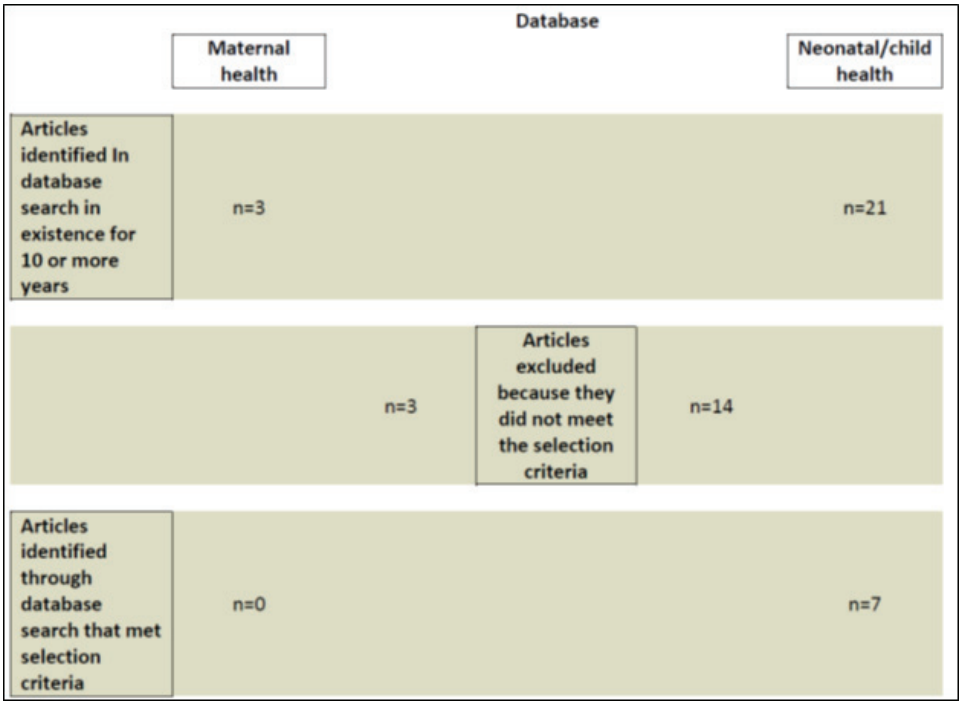


Figure 1. Selection of projects with long-term evidence of impact on maternal or neonatal/child health through integrated community-based primary health care (CBPHC).

Table 1. Reasons for exclusion of assessments of projects of 10 or more years' duration

Reason for exclusion	Projects of 10–year duration or more excluded from analysis	
	Maternal database	Neonatal/child health database
No measure of mortality included	1	5
No baseline measure of mortality	2	2
Mortality impact data covered less than 10 years of programming		2
Only 1 intervention implemented		3*
No evidence or mortality impact		1
No comparison area		1
Total	3	14

*Vitamin A in one assessment, malaria control in one assessment, and conditional cash transfers in another assessment.

The remaining seven assessments [2–8] that qualified for the analysis concerned four projects:

- The icddrb MCH–FP project in Matlab, Bangladesh;
- The Hôpital Albert Schweitzer in Deschapelles, Haiti (which operates a CBPHC program);
- The Jamkhed Comprehensive Health Project in Jamkhed, India; and,
- SEARCH (Society for Education, Action and Research in Community Health) in Gadchiroli, India.

Additional literature on these projects was reviewed, and additional findings were incorporated based on personal experience and field visits of one of the authors (HP) to these projects along with personal communications with persons engaged in these projects. By coincidence, Dr Perry worked in Bangladesh from 1995–1999 and visited the Matlab field site on a number of occasions. He served as Director General/CEO of the Hôpital Albert Schweitzer in Deschapelles, Haiti from 1999–2003. He has visited the CRHP project on four separate occasions (1998, 2004, 2006 and 2009) and the SEARCH project on two occasions (2004 and 2006).

RESULTS

The four projects identified from our database that had evidence of under–5 mortality impact for 10 years have each been functioning for 30 years or longer and are still functioning. These projects also had considerable evidence of improvements in coverage of key evidence–based interventions. These four projects are:

- The icddrb MCH–FP project in Matlab, Bangladesh (a maternal/child health and family planning research field site for icddrb, formerly known as the International Centre for Diarrhoeal Disease Research, Bangladesh);
- The Hôpital Albert Schweitzer in Deschapelles, Haiti;
- The Jamkhed Comprehensive Health Project in Jamkhed, India; and,
- SEARCH (Society for Education, Action and Research in Community Health) in Gadchiroli, India.

Here we describe below the main features of these projects, recognizing that over such a long period of time these features have not remained static. Nonetheless, the descriptions are appropriate for the time in which the mortality impacts were achieved even though they may not entirely accurately describe current activities.

The Icddrb MCH–FP project in Matlab (Bangladesh)

Project description

The Cholera Research Laboratory (CRL) was established in 1960 in Dhaka, Bangladesh to develop methods for preventing and treating cholera. In 1963, the CRL established a field site in a rural riverine area three hours southeast of Dhaka in a cholera–endemic area to test new approaches for controlling the disease, including the testing of the effectiveness of new cholera vaccines. In 1966, a Demographic Surveillance System (DSS) was established at Matlab with the initial goal of assessing the impact of new vaccines on morbidity and mortality. The DSS has become the oldest demographic surveillance system in the world, and Matlab is the site of hundreds of field research projects regarding health, nutrition, population and socio–economic development. The CRL expanded its work to maternal/child health and family planning in 1977, and in 1978 the Government of Bangladesh established the International Centre for Diarrheal

Disease Research, Bangladesh (now icddrb), which took over responsibility for the Matlab DSS and field activities [9–11].

The field site is divided into two parts. The first is an Intervention Area, where intensified community–based health and family planning activities operated by icddrb began in 1977. This is the Maternal–Child Health and Family Planning (MCH–FP) project. The second is a Comparison Area, where only government health services are provided. Each of these two areas has a population of approximately 112 000 persons.

Eighty paid community health workers (CHWs) in the Intervention Area visit each home on a regular basis. (The frequency of visits has declined gradually from every two weeks in 1977 to every two months at present.) Each CHW is responsible for approximately 200 households and typically visits 20 homes per day. At the time of a home visit, the CHWs immunize women and children, provide antenatal and postnatal care, and treat childhood pneumonia according to WHO guidelines. They provide nutrition education and treat diarrheal disease. They also leave packs of oral rehydration salts (ORS) with a "depot holder," who is a mother in the neighborhood with additional training in the treatment of childhood diarrhea. Finally, the CHWs promote family planning, distribute birth control pills and condoms, administer injectable contraceptives and track pregnancies.

The CHWs working in the icddrb MCH–FP project are well–trained and well–supported, and they can refer patients to a nearby sub–center staffed by a full–time paramedic who provides routine maternal and child health care as well as reproductive health care. A hospital operated by the project is readily available for referrals. This referral system and readily available hospital care was a key element of the initial CRL activity since the survival of patients with cholera depended on prompt identification and transport, usually by boat in this riverine environment, to the hospital in Matlab operated by the CRL. The project earned a high level of trust with the population because of the high quality of health care it has provided over four decades. Maintaining good relations with the community is a priority for the Matlab MCH–FP project, and project managers promptly address any issues raised by the community about the quality of services or the nature of the field research activities. The total annual cost per capita for the community–based portion of the health project (excluding research–related expenses) is about US$ 5 [12].

Four sub–centers are located in the Intervention Area (one for about 28 000 people), and 20 CHWs are assigned to each sub–center, where a full–time paramedic works. CHWs meet at the sub–center every two weeks for supervision, continuing education, and replenishment of supplies. Basic comprehensive primary health care is provided by the paramedics, including insertion of IUDs, menstrual regulation (suction curettage of the uterus for women with delayed menstrual periods who do not want to become pregnant), and treatment of sexually transmitted diseases and reproductive tract infections. Icddrb also operates a 50–bed inpatient facility that serves the Intervention Area. A government district hospital serving a larger geographic area is also in Matlab. Major surgical procedures are not available at the icddrb Matlab facility, but emergency obstetrical care, including caesarian section, is provided in collaboration with the government district hospital in Matlab [12].

Key components for success at Matlab include:

- Sound organizational structure from the outset;
- Readily available transport throughout the project area, mostly by speedboat, which has facilitated patient referral to the Matlab Hospital;
- A strong system of accompaniment and support for all levels of workers;
- A well–developed record–keeping system; and
- Continuously available supplies.

The book *Matlab: Women, Children and Health* provides a full discussion of the history of Matlab, its operations and research findings through the early 1990s [10].

Long–term outcomes

In 1984, the contraceptive prevalence rate (CPR) in the Intervention Area was 46% compared while it was 16% in the Comparison Area and 19% nationwide. In 2005, the CPR in the Intervention Area was 71%, 47% in the Comparison Area, and 58% nationwide. In 1987, the coverage rate for the standard series of childhood immunizations was 69% in the Intervention Area compared to a national rate of approximately 20% nationwide [12]. In 2005, the childhood immunization coverage rate in the Intervention Area was 97% compared to 85% in the Comparison Area.

Between 1988 and 1993, the mortality rate from pneumonia in children younger than 2 years of age was 54% lower in the Intervention Area than in the Comparison Area [13]. There was a reduction by around 75% in the annual number of childhood deaths over a 25–year period in Matlab, and over a 40-year–period, life expectancy increased from 50 to around 65 years [10].

The infant and 1– to 4–year mortality rates for the Intervention Area of MCH–FP project area were consistently lower than in the government services area (the Control Area) over a 15–year period between 1978 and 1994 [14,15]. In 1985, the under–five mortality rate (U5MR) per 1000 live births was approximately 200 in the Comparison Area and 150 in the Intervention Area (25% less). In 1995, the rates were approximately 120 and 75 respectively (38% less in the Intervention Area). In 2005, the under–five mortality rate was 46.6 in the intervention area and 62.4 in the Comparison Area (25% less) [14,15]. Over the period from 1982 to 2005, the maternal mortality rate (that is, the number of maternal deaths per 100 000 women of reproductive age) was 37% lower in the Intervention Area than in the Comparison Area, mainly as a result of a lower pregnancy rate and lower case–fatality rates for induced abortion, miscarriages and stillbirths [16].

The total fertility rate (TFR) over time has been the following: in 1985, the TFRs were 4.5 in the Intervention Area and 6.0 in the Comparison Area; in 1995, they were 3.0 and 3.6 respectively; by 2005, the rates were essentially the same at 2.7 and 2.8, respectively [14,15].

The progress in the Control Area can be attributed in part to the national application of the Matlab family planning model of home visits by paid workers to promote the use of family planning and the distribution of birth control pills and condoms. By the mid–1980s, Bangladesh essentially had a national CHW program. Progress in increasing the use of facilities for giving birth was slower in the Comparison Area. In 2004, only 12% of the births in the Comparison Area were taking place in a facility while in the Intervention Area the corresponding figure was 50% [14,15].

Lessons learned

Two lessons learned at Matlab and reported in 1994 bear emphasis here:

- "Family planning field workers are more likely to gain the confidence of the community if they respond to other health problems, particularly those of women and children.... [T]he benefits of integrating quality health services into a family planning programme justify the heavy inputs" [17].
- "The successful operation of such a large and multifaceted project as Matlab requires a professional level of organization in the hands of a competent manager. This applies for staff management, logistics and supplies, and relations with the community" [17].

One of the striking findings from the Matlab example is how quickly child mortality in the Comparison Area declined and how the difference between the Intervention and Comparison Areas gradually narrowed later. The differences in mortality rates for infants and children between the Intervention and Comparison Areas have narrowed over time. This can partly be explained by the fact that the MCH–FP Project at Matlab served as a model of CBPHC for the country, and Bangladesh has done a masterful job of extending home–based services – both MCH and FP services – throughout the country. Bangladesh is one of only 19 out of 68 high–mortality countries that reached the Millennium Development Goal for children by 2015 [18], and its national achievements in expanding coverage of community–based services has been widely documented and applauded [19]. After the interventions of the Matlab MCH–FP Project were proven to be effective in the 1970s, there was an explicit effort in the 1980s to introduce this same strategy nationally, with obvious benefits.

Hôpital Albert Schweitzer (Deschapelles, Haiti)

Project description

L'Hôpital Albert Schweitzer (HAS) began operations in 1956 after a wealthy American couple, William Larimer and Gwen Grant Mellon, were inspired by the example of the great medical missionary Albert Schweitzer who, for more than a half–century, provided medical care in Gabon, an underserved country of West Africa. The Mellons constructed one of Haiti's first modern hospitals in the Artibonite Valley, three hours northwest of capital, Port–au–Prince [20].

For the first decade of its existence, HAS provided only hospital care and services at an outpatient clinic based at the 190–bed hospital. In its second decade (in 1967), it established a project of community–

based primary health care based on community health workers (*agents de santé*) and mobile health teams without any peripheral primary health care facilities. Over time, seven health posts and two health centers opened. The hospital always served as the Ministry of Health's district hospital for the health district in which it is located, with 258 000 people in its catchment area during most of the period covered by the impact assessment. The population served by HAS's primary health care project fluctuated over the years, from 18 820 in 1958 to 180 000 in 1996 and to 350 000 in 2016 [3,20].

In the 1960s, HAS also established community development activities, including projects for improving water and sanitation at the village and household levels, promoting vegetable gardens and reforestation, providing opportunities for micro–credit and income–generation for women, literacy training, support for primary education, and promotion of animal husbandry and improved agricultural production. HAS thus became a comprehensive integrated health and development system with strong CBPHC services together with facility–based primary health care, hospital referral care and community development activities [3].

The CBPHC services at HAS have relied on paid Health Agents (*Agents de Sante*) who regularly visit every home to provide basic health education, register vital events, and mobilize mothers and children to attend Rally Posts where essential services are provided, including immunizations, growth monitoring/promotion, and referral care at the hospital. Mobile clinics reach all isolated areas intermittently. These are staffed by an auxiliary nurse who, every 1–2 months, visits isolated communities on foot (since there are few roads in the mountains) to provide basic curative and preventive care (including family planning) and to refer patients when needed.

In the late 1990s, 1500 volunteer community health workers (*Animatrices*), one for every 15 households, were recruited to provide peer–to–peer health education to other women, to assist with the Rally Posts and Mobile Clinics, to promote community involvement, and to assist with referral of patients to higher levels of care [3]. In addition, eight Monitors (*Monitrices*) provide liaison with and training of lay midwives, along with supervising and training the *Animatrices*. The role of *Monitrices* at HAS initially involved supervising the community–based nutritional rehabilitation project, known as the Hearth Project, which originated at HAS and has been implemented in numerous other countries. Finally, the CBPHC services at HAS include 16 community–based tuberculosis workers (seven *Accompagnateurs* and nine *Agents*) who obtain sputum specimens from symptomatic patients and provide directly observed therapy for patients in their home. Community–based provision of anti–retroviral medication for patients with HIV/AIDS is now provided as well.

Steady financial support from external donors has been available to HAS since its inception, and this has helped HAS to provide high–quality professional leadership and management. It has been able to ensure logistical support for its field projects and to provide needed supplies and drugs. The quality of its clinical services has earned the trust and support of the population over a long period of time. The hospital is widely regarded as one of the best district hospitals in a rural area of a developing country, and patients from throughout Haiti have come there for treatment.

Long–term outcomes

In 2000, population coverage rates of key child survival interventions in the HAS primary health care service area were approximately twice those for the same interventions nationwide in rural Haiti. Additionally, the U5MR in the HAS service area was less than half of that for Haiti overall (62.3 vs 149.4) [3]. Likewise at that time, the CPR in the HAS project area was nearly double that in other areas (27.5% vs 15.4%) [3]. Great efforts have been made to ensure access to basic services in the most isolated parts of the HAS project area, some of which require eight–hours by foot to reach.

As a result of the collection of vital events data at the time of initiation of HAS's community health project in 1967 [21] and the intermittent collection of retrospective birth histories since, it has been possible to monitor the U5MR for the primary health care project area served by HAS and to compare these to data for Haiti as a whole. The HAS project area is similar in socio–economic indicators to rural Haiti as a whole [4].

The U5MR in the HAS primary health care service area remained much lower than in Haiti nationally over a three–decade period from 1970 to 1999 [4]. The rapid decline in under–five mortality to one–quarter of the national level between 1958 and 1973 was due in large part to the elimination of neonatal tetanus through immunization of all women of reproductive age [22,23]. Between 1970 and 1999, the U5MR remained less than half that of the U5MR for Haiti [4].

The per capita annual cost for the entire project as it existed in 1999 would be US$ 24.77 in 2016 dollars. Because of resource constraints, the projects at HAS have undergone significant cutbacks over the past decade. The cost per under–five death averted in current dollars was US$ 3233; the cost per year of live saved was US$ 47; and the cost per DALY saved was US$ 90 [24].

Lessons learned

There does not appear to be any single intervention or even a small set of interventions responsible for the sustained mortality reduction. Rather, the entire system of health and development – community–based services, primary health care services at health posts and health centers, hospital services, community development projects, as well as the interactions between these elements – most likely contributed to this mortality impact. The close integration of the CBPHC activities with the primary health care facilities and the hospital are key elements of system effectiveness.

The rapid decline of mortality for Haiti as a whole during the period from 1970–1999, is worth noting, particularly in light of the country's political instability, its deteriorating economic situation, and the epidemic of HIV/AIDS throughout the country, which began in the early 1980s. In fact, in spite of the devastating earthquake in the capital in 2010 and more recent cholera outbreaks, Haiti is one of only 34 of the 74 so–called Countdown Countries (with 97% of world's maternal and child deaths) to have achieved the Millennium Development Goals in 2015 for reduction in child and maternal mortality [25]. The model of CBPHC developed at HAS is now utilized by virtually all other NGOs working in community health in the country, and these NGOs provide community–based child survival services to two–thirds of the population of Haiti. The nationwide contribution of CBPHC to the gains achieved in child survival in Haiti have been possible in part because of the early experience at HAS and its position as a role model for the rest of the country.

India: the Jamkhed Comprehensive Rural Health Project

Project description

The Jamkhed Comprehensive Rural Health Project (CRHP) in Ahmednagar District of Maharashtra, India, has been in operation for almost five decades [5,26]. It developed a comprehensive approach to community–based health programming in conjunction with first–level hospital referral services. Its principles of equity, integration and empowerment have been guiding principles throughout this prolonged period.

When CRHP began in 1970, the people of the Jamkhed area were living in near–famine conditions from drought and lack of access to water. The prevalence of childhood malnutrition was 40%, and coverage rates of childhood immunizations, family planning, prenatal care, and birth attendance by a trained provider were all less than 1%; and the infant mortality rate was 176 per 1000 live births. The caste system was ingrained, and harmful traditional practices, especially for women, were common. In addition, women had no personal rights. Furthermore, they were often treated inhumanely. One–third of the population was migrating to sugar cane plantations outside of the district to work in temporary jobs because of the scarcity of food and the lack of work in the Jamkhed area.

Rajanikant and Mabelle Arole started working in Jamkhed in 1970 as a husband–wife physician team treating patients who came to them with medical problems. They quickly realized that over three–quarters of health problems could be addressed at the community level, mainly by the villagers themselves, if they had a modest amount of additional knowledge and skills. The main purpose of their work soon became to facilitate a process whereby communities could improve their health through their active participation by learning about and addressing their problems based on their own priorities.

Some of the initial activities carried out were: health promotion through health education, immunization, prenatal care, complementary infant feeding, ensuring safe delivery, family planning, and a health center for curative care. Their work gradually expanded to train illiterate CHWs, address the determinants of ill–health through improving access to water and food, nutrition education and kitchen gardens, women's and community empowerment, micro–credit, education, improved agriculture, and prioritizing the needs of the poorest and most disenfranchised members of communities. From the beginning, CRHP worked only with communities that requested assistance and committed themselves to participation. Gradually, all villages in the area sought to be involved as they saw the benefits to other communities from participation.

CRHP always insists on major investments of time and energy from community members as a condition of CRHP's entering into partnership with a community, so the process that emerged ensures future sustainability. The project established groups of volunteers within the community, including village health workers (VHWs), farmers' clubs and women's groups (*mahila mandals*), and, more recently, girls' and adolescent boys' groups.

The key change agent in the community became the VHW, who is selected by the community. She is eager to assist her village, especially the poorest and most marginalized members such as *Dalits* (untouchables) and those with stigmatized conditions (such as leprosy). She receives training in health, community development, communication, organization and personal development. Her primary role is to share her knowledge with everyone in the community, to organize community groups, and to facilitate the community's assessment of problems and resources, analysis of causes and determinants, and appropriate actions, especially with the poor and marginalized that might be undertaken with the assistance of CRHP. Initially, many of these VHWs were illiterate women from the untouchable (*dalit*) caste who had recovered from an illness (such as tuberculosis) as a result of care provided by CRHP.

Although the VHWs do not work for pay, with project assistance they obtain access to income–generating activities. They serve as a link between the community and the project's mobile team, which visits each village once a month or more often if needed. The mobile team consists of a nurse, an agricultural specialist and a social worker, though they all become multipurpose workers through working together, learning from each other, and additional training.

The VHWs come to the project center in the small town of Jamkhed once a week. There they meet with the other VHWs to discuss problems encountered in their work and to obtain further training from each other and from staff. They spend the night there and provide social support for each other. Many of the VHWs have been working for more than 30 years. Dropouts are rare, mainly because of old age and death.

For many years, CRHP operated a 30–bed hospital that served as a referral source for patients from the project area and beyond. A larger 50–bed hospital has recently been completed. Emergency cesarean section and other emergency surgical procedures are performed there. At the beginning of the project, the hospital in Jamkhed was filled with children who had life–threatening infections and malnutrition. Such patients are rarely seen there now.

CRHP gradually expanded to reach 300 villages with a population of 500 000 people. Most of these villages are now independent, thanks to the sustainable development process that CRHP has nurtured over five decades, so CRHP now focuses on the villages that need them most.

Because of the great interest of people throughout India and the world to learn about the CRHP experience, the Jamkhed International Institute for Training and Research in Community Health and Development was established in 1992. More than 30 000 people from throughout India and more than 3000 people from over 100 countries have come there to learn from the VHWs, other villagers and CRHP staff and to visit villages to see the impact firsthand.

Each village maintains a record of all births and deaths that take place among its members, as well as records of the number of eligible couples who are using family planning, the number of children completely immunized, and the number of children with malnutrition. Also included is information about socioeconomic conditions, agricultural and environmental issues, and various priority diseases. This information is written on a board that is displayed in a public space in the village and services as a focal point for discussions about priorities for the community to address. Participatory Rural Appraisal (PRA) techniques are commonly used for assessments and analysis as well as for discussions on what to do. All segments of the community participate.

Long–term outcomes

By 1993, the percentage of pregnant women with antenatal care and a safe delivery reached 82% and, in 2011, it reached 99%. The percentage of couples utilizing family planning reached 68% in 2004. In 2004, 87% of children were fully immunized and only 5% were undernourished according to anthropometric measurements. This low prevalence of undernutrition has been maintained ever since. Leprosy, which was common at the start of the project, has virtually disappeared, and the incidence of tuberculosis has declined from 1800 to 200 cases per 100 000 persons [26].

The IMR at CRHP Jamkhed declined from 176 deaths per 1000 live births in 1971 to 19 in 1993 [5] to 8 in 2011, according to data collected at CRHP by CHWs [26]. In 1971, the IMR at CRHP Jamkhed was

60% greater than for the rural area of the state of Maharashtra (176 vs 110), but since 1980 the IMR at CRHP Jamkhed has been half that for rural Maharashtra [27]. A large–scale external and independent evaluation of the mortality impact of CRHP based on a comparison of findings from birth histories in project villages with those in a surrounding control area was carried out in 2007–8. This evaluation demonstrated a 30% reduction in the risk of death among children 1–59 months of age in CRHP project villages compared to control villages [28].

Although baseline levels of maternal and perinatal mortality were not measured in the 1970s when CRHP began, these rates were measured following a careful review of all births and deaths in 25 villages around Jamkhed between 1996 and 1999. A maternal mortality ratio of 70.0 per 100 000 live births and a perinatal mortality rate of 36.0 per 1000 live births and stillbirths were measured at CRHP [29]. These rates were 27.8% and 20.3% lower respectively than the maternal and perinatal mortality for Pune district in Maharashtra State in India, were the CRHP is located [29].

These significant results were accomplished because of the communities' participation and empowerment together with their understanding of health promotion and disease prevention. For example, family members know the importance of healthy nutritional practices, prenatal care, how to provide early home care for common problems (such as homemade oral rehydration solution for diarrhea, steam inhalation for respiratory problems, sponging with cool water for fever, and sunlight for neonatal jaundice). VHWs ensure exclusive breastfeeding for infants during their first 6 months of life, proper burping after feeding, and nutritional weaning foods. The men and women's groups weigh the children for growth monitoring. Immunizations were also gradually accepted by the communities as the program developed. The government now provides these services with the support and cooperation of the VHWs and community groups.

In the early years the communities organized feeding programs for groups of children, with everyone contributing something (eg, firewood, water, salt, grains, or pulses), and the Farmers' Clubs dedicated some of their land for growing food for the program. They established watershed development projects to increase the available of groundwater for home and agricultural use. Most homes now have kitchen gardens for additional, nutritious fruits and vegetables.

Lessons learned

To be sure, the impact of CRHP is demonstrated through changes in health statistics, which show positive results achieved over more than four decades. Behind these statistics are self–confident men and women, once outside the mainstream of society, taking leadership positions in their villages, affirming that they have God–given dignity, worth and capacity. Thus, it is not only the quantitative changes that are important. Even more important is the transformation of persons and communities in a qualitative way, which have made these health improvements possible.

Community empowerment increases self–reliance, self–esteem, self–confidence – and it reduces dependency on outside agencies. In order for the development process to be sustainable by the people, the community must have good leadership and the capacity to address its own issues. In the Jamkhed process, the community learns to work together and solve problems together. If the community needs more knowledge, skills or resources, CRHP helps them.

The Jamkhed process of sustained health improvement through CBPHC involves:

- Expanding knowledge and skills through building the capabilities of individuals and communities, based on where they are and what they have.
- Developing a caring and sharing community that promotes reconciliation and peace (*shalom*) by engaging the whole community, including the poorest and most marginalized members and integrating them as active members of the community to solve the problems that concern them most through assessment, analysis, and action.
- Promoting volunteerism by building a community of motivated and caring individuals committed to engaging in these activities.
- Focusing on low–cost activities including home remedies and herbal medicines as well as health promotion, prevention, early detection, treatment, and rehabilitation in the community.
- Utilizing appropriate technology and local resources that are accessible in the context of the community's knowledge, skills and interests.

- Engaging in multi–sectoral development, including education, sanitation and income generation, as well as building social capital and helping people to recognize the harm that some traditional practices are causing for the purpose of improving the overall well–being of the community, recognizing that conditions outside of the health sector have more impact on health than curative care alone.
- Recruiting, training and supporting women VHWs, who are so motivated that after decades of service they are still active leaders, still learning and sharing with their communities and others.

This transformative process is spread to other communities by the villagers who have experienced it, making it a people's movement. This is not an innovation in technology but rather an innovation from within each community that brings about social change and thereby uplifts everyone from poverty and disease. Lives are transformed by embracing the dignity and worth of everyone and giving an opportunity to all to contribute.

CRHP is one of the world's leading examples of improving MNCH through community empowerment, women's empowerment and community participation. In spite of not being well–known in academic and research circles, it is well known in the broader global health community through the visits of thousands of people from throughout India and around the world as well as through the 1994 publication of the acclaimed book by the Aroles, simply entitled *Jamkhed: A Comprehensive Rural Health Project* [5]. This book is one of the best long–term sellers among global health books and has been translated into a number of different languages.

Of historical importance is the fact that the CRHP served as one of the inspirations for the 1978 International Conference on Primary Health Care at Alma–Ata. CRHP was one of the projects featured in the influential monograph published by the World Health Organization several years prior to the Conference [30,31]. In contrast to the limited information in most peer–reviewed scientific articles regarding the context within which CBPHC operates and how it is actually implemented in the community, there is extensive information about these benchmarks in the acclaimed book by the Aroles [5].

SEARCH (Society for Education, Action and Research in Community Health) in Gadchiroli, India

Project description

Since 1986, the Society for Education, Action, and Research in Community Health (SEARCH) has provided community–based health care services and hospital care in a rural area of the state of Maharashtra, India, known as Gadchiroli [32,33]. The Gadchiroli District is the least developed in the state. The district is largely forested, and half of the inhabitants are indigenous tribal people who live in the forest. The other half is composed predominantly of Hindu subsistence farmers. Gadchiroli is 175 km south of Nagpur in the most western part of Maharashtra.

The founders, Dr Abhay Bang and Dr Rani Bang, were inspired by the life of Mahatma Gandhi and established their work in the context of Gandhian social philosophy. They developed a collaborative partnership with the communities of Gadchiroli for basic health care, education and training in health, and for research to inform health policies [34]. Like the Aroles, who founded the Jamkhed CRHP Project, the Bangs obtained important insights for their work from the Narangwal Project, a model community health project established in collaboration with the Johns Hopkins University in the 1970s [35,36].

The Bangs established three goals for their organization: (1) provide health care to the local population, (2) provide training and education in health, and (3) conduct research to shape health policies. The vision of SEARCH is the realization of *Aarogya–Swaraj* (translated as "the people's health in people's hands") by empowering individuals and communities to take charge of their own health, thereby helping them achieve freedom from disease as well as from dependence. The mission of SEARCH is expressed in its name, "Society for Education, Action and Research in Community Health." The mission is "to work with marginalized communities to identify their health needs, develop community–empowering models of health care to meet these health needs, to test these models by way of research studies, and then to make this knowledge available to others by way of training and publications" [32]. Thus, community–based primary health care, community participatory research and training of village people are core activities at SEARCH.

Over the past 30 years, Drs. Abhay and Rani Bang and their dedicated staff developed a community health project that provides community–based primary health care for a population of 80 000 people. One–half of this area is used as a field site for implementing new interventions while the other half serves as a con-

trol area in the sense that the new intervention is not being implemented there during the study period. SEARCH also operates a 20–bed hospital and outpatient facility to serve tribal people from the area.

SEARCH pioneered the development of a community–based reproductive health care project and related research. It also developed a pioneering community collaboration to address alcohol and drug addiction, which was initiated in response to requests from the community [37]. Basic surgical services are provided at the hospital, including cesarean sections and surgical care for a common cause of long–term disability – massive hydrocele caused by lymphatic filariasis. Patients requiring higher levels of care are transported to a government hospital in the city of Gadchiroli, which is about 30 minutes away. The staff at SEARCH consists of 30 members, including physicians, paramedics, project supervisors and managers, and research staff.

SEARCH established a partnership with communities over the past two decades by listening to members, responding to their expressed concerns and priorities, and involving them in the planning, implementation and evaluation of its projects. The community has taken co–ownership of the project.

SEARCH does not duplicate the government health system. Instead, it has developed a community–based health provision system that utilizes the government health system for referrals. SEARCH employs, trains and supervises one female community health worker (CHW) for approximately every 1000 population. This CHW visits every home on a monthly basis, registers pregnancies, births and deaths since the previous visit, and provides health education and basic preventive and curative health care. By maintaining close contact with the households for which she is responsible, the CHW is able to provide childhood pneumonia treatment and home–based neonatal care along with other basic health care services for mothers and children. Between 1988 and 2005, SEARCH also provided strong training and support for the traditional village midwives (*dais*).

The Bang's groundbreaking research on the effectiveness of community–case management of childhood pneumonia [38] and on the effectiveness of home–based neonatal care [2] has had a major impact on health care programs throughout the developing world. The project relies on trained traditional birth attendants and community health workers for diagnosis and treatment of common illnesses, diagnosis and treatment of childhood pneumonia, and provision of home–based neonatal care.

Long–term outcomes

The infant mortality rate in the Intervention Area declined by 74%, from 120 deaths per 1000 live births in 1988 to 31 in 2003 [2,39]. In the Comparison Area, over the period of time for which data have been reported (1994–2004), the IMR remained essentially unchanged [2,39]. This was the period during which the home–based neonatal care intervention was being implemented and evaluated.

Lessons learned

The pioneering findings of the community case management of pneumonia and of home–based neonatal care by SEARCH in Gadchiroli have stimulated much additional work by others around the world since the efficacy of these interventions were first reported by the Bangs in the 1990s [38,40]. The Bangs provided leadership for replication of the home–based neonatal care intervention by other NGOs in the state of Maharashtra, and they provided technical assistance for scaled–up versions of the SEARCH model for home–based neonatal care now being tested by the India Council of Medical Research at various sites around India.

Among other things, their work has demonstrated that properly trained, supervised and supported CHWs, even if they are illiterate, can provide high–quality technical interventions for mothers and children. The methods of selection, training and support of CHWs used by SEARCH merit closer analysis and widespread application.

DISCUSSION

The Matlab MCH–FP project in rural Bangladesh, the HAS integrated project of health and development in rural Haiti, the Jamkhed CRHP in rural India, and the Gadchiroli SEARCH project in rural India are among the few examples that exist of projects with evidence of long-term reductions in maternal, neonatal or child mortality resulting from community–based interventions. Three of the four of these projects have been in operation for more than four decades, while the fourth (SEARCH) has been in operation for more than three decades.

Common characteristics of projects with evidence of long–term impact on mortality

What is particularly striking is the similarity of many of the features of these projects. As **Table 2** demonstrates, all four of these projects are similar in the broad range of services they offer along the continuum of care for individuals at various points in the life cycle – from pregnancy and childbirth to the neonatal and child periods to adolescent and adulthood. They are also similar in the breadth of types of services – from preventive to curative to rehabilitative services. Finally, they are similar in the vertical integration of their services – from home–based and community–based services all the way to hospital referral services.

Another characteristic these projects have in common is that they all have a strong community–oriented health system in which the community is a partner. Improving MNCH is one of many goals of the health system that these projects developed. However, they all also provide comprehensive primary health care services with a strong focus on maternal and reproductive health and family planning. They all provide hospital services and ensure that basic surgical care is available to the populations they serve. They all recognize the importance of a functioning referral system to ensure that patients can access higher levels of care when needed. Most importantly, all four of these integrated comprehensive projects have established strong CBPHC services that serve as a foundation upon which the other project activities rest. These CBPHC services all include strong collaborations and partnerships with communities.

All projects have strong professional leadership as well as dynamic management and supervisory systems. They ensure that essential supplies and drugs are available. They all have a record of treating patients with a high level of respect.

The projects have been developed and sustained with a high level of community engagement; the community has a high level of trust in the health services provided by the projects. The provision of a broad array of high–quality curative services by each of these projects over a long period of time has resulted in trust being developed with the communities.

A final important similarity is that all four projects created strong roles for community–level workers. The projects all realized their effectiveness would be compromised without building a central role for these workers, all of whom receive some type of financial assistance. These CHWs all receive high–quality training and supervisory support. They maintain routine contact with all families in service areas, and they provide essential health care in their homes and at readily accessible sites in the community and nearby.

These four projects have all influenced thinking and practice in CBPHC programming for MNCH around the world – through their research as well as through their influence on younger people who have had personal experiences in the field with these projects who later become global health leaders. And, of course, CRHP's influence on the emergence of primary health care as defined at Alma–Ata as well as on the later emergence of national CHW programs in India is well–known [31,41].

The findings reported in this paper have focused on long–term improvements in neonatal and child health. But, it is important to point out that two of the four projects included here also have evidence of long–term reductions in maternal mortality: Matlab MCH–FP [10] and CRHP [29]. Exploring these findings in detail is beyond the scope of this article, but suffice it to say here that presence of strong CBPHC interventions for reproductive and maternal health (including family planning) linked to well–developed referral systems and readily available hospital care serve as the foundation for preventing maternal deaths.

Another interesting shared characteristic is that each of the four projects has a "culture" of science and evaluation, which led to the reporting of outcomes and the inclusion of these four projects in our review. These projects have been at the forefront of generation of knowledge about effective programming based on their field experiences.

A final shared feature of these four projects is their strong connection to the Narangwal Project and Dr Carl Taylor. We noted previously that both CRHP and SEARCH were directly influenced by the Narangwal Project, a pioneering field project in north India during the late 1960s and early 1970s that was one of the first to carefully evaluate the effectiveness of community–based primary health care [26,35]. The Aroles and the Bangs were master of public health students of Dr Carl Taylor's at the Johns Hopkins University, where they learned about the Narangwal Project. The CBPHC work at icddrb was directly influ-

Table 2. Common characteristics of four projects with long–term evidence of impact on child mortality*

Characteristic	Hôpital Albert Schweitzer (Haiti)	Matlab MCH–FP project (Bangladesh)	CRHP–Jamkhed (India)	SEARCH–Gadchiroli (India)
Basic project characteristics:				
Year established	1956	1965	1970	1986
Population of catchment area	150 000	100 000	300 000	80 000†
Range of services provided:				
Is a comprehensive array of child health services provided? These include health and nutrition education, diagnosis and treatment of acute childhood illness, referral of seriously ill children to a higher level of care.	Yes	Yes	Yes	Yes
Is a comprehensive array of maternal, reproductive health, and family planning services provided? These include health and nutrition education, provision of antenatal care, management and/or referral of obstetrical complications, provision of postnatal care, and provision of a wide range of family planning methods	Yes	Yes	Yes	Yes
Are general curative services provided? These include treatment of common childhood illnesses and management (including referral when indicated) of serious childhood illnesses in the community; care for acute illnesses among patients of all ages in health centers, and referral of seriously ill patients to higher levels of care.	Yes	Yes	Yes	Yes
Are surgical and/or other hospital inpatient services provided?	Yes (operates its own first–level referral hospital with advanced surgical capabilities)	Yes (operates its own first–level referral hospital with no surgical capabilities)	Yes (operates its own first–level referral hospital with advanced surgical capabilities)	Yes (operates its own first–level referral hospital with some surgical capabilities, eg, cesarean section)
How strong is the referral system from the community to higher levels of care at fixed facilities, including hospitals? In all four projects, a first–level referral hospital is integrated into the project. However, all surgical cases at Matlab are referred to the government district hospital as are more complicated surgical cases at Jamkhed and SEARCH.	Very strong	Very strong	Very strong	Very strong
Health project management and support:				
Does the project have a strong system of management and supervision led by competent and dedicated professionals?	Yes	Yes	Yes	Yes
Does the project have a record of accomplishment in treating patients and clients with a high level of respect?	Yes	Yes	Yes	Yes
Does the project have a record of maintaining supplies and drugs?	Yes	Yes	Yes	Yes
Nature of community partnerships/community involvement:				
How strong is the partnership between the project and the community?	Fairly strong	Fairly strong	Very strong	Very strong
How strong is the level of trust of the community in the project?	Very strong	Very strong	Very strong	Very strong
Role of community–based workers:				
Are CHWs an integral part of the project?	Yes	Yes	Yes	Yes
Do CHWs receive financial support?	Yes	Yes	Yes‡	Yes
How strong is the training and support of CHWs?	Very strong	Very strong	Very strong	Very strong
Do CHWs have routine contact with all families through visitation of all homes?	Yes	Yes	Yes§	Yes
Do CHWs provide essential child health services in the home?	Yes	Yes	Yes	Yes

CHW – community health worker

*Some of this information is based on the authors' field observations and discussions with project leaders and is not contained in written documents.

†The part of the SEARCH project area with documented declines in infant mortality has 40 000 people.

‡Although the CRHP CHWs do not receive a salary, they do receive special training and access to credit to enable them to become economically self–sufficient through their own income–generating activities. CRHP ensures that their CHWs have enough income to meet their needs.

ence by the Narangwal Project as well because the director of fieldwork for that project, Dr Shusham Bhutyia, later initiated the training and support of CHWs for the Matlab MCH–FP project. The CBPHC work at HAS in Haiti was led by Drs. Warren and Gretchen Berggren, who were mentored in this by Dr John Wyon, a colleague of Dr Carl Taylor's in north India and the field director for the Khanna Study [42], a community–based field research project that served as a predecessor of the Narangwal Project. Dr Carl

Taylor served as a mentor to John Wyon during the development and implementation of the Khanna Study and they remained close colleagues subsequently.

However, in spite of these many shared characteristics, there are important differences to note as well. There are notable differences in the four projects in terms of the degree to which they have engaged in research and reported their results in peer–reviewed journals. The Matlab MCH–FP project is one of the world's foremost field research sites. SEARCH has been the site of some of the most influential research in global health related to community–case management of pneumonia and home–based neonatal care. Although HAS and CRHP have been the site of important research, these two projects have had less of a research orientation and more of a service orientation.

The Matlab MCH–FP project differs importantly from the other three in that it functions within the strong institutional framework of an international research center without an obvious single strong small set of long–term leaders. The projects each had two key individuals who led them from the beginning over a long period of time. CRHP is notable compared to the others in its deep commitment to field–based education of thousands of people from around India and beyond who have come to learn about CRHP's approach to working with communities and CHWs.

Criticisms have commonly been made of smaller "model" CBPHC projects because (i) they are not sustainable and not scalable since they are dependent on charismatic leadership and (ii) they have not had to deal with the management and logistical challenges of operating a program at larger scale, which are an order of magnitude more difficult. From the standpoint of these four projects, it is obvious that they are sustainable because of their long–term operation. None of these projects attempted to go to scale, but in every case certain elements of each project have in fact been scaled up in an indirect sense. The Matlab MCH–FP Project, once proven effective, served as the model of government national scale up of CHW programming. HAS's approach to CHWs has been adopted by virtually all other NGOs providing community–based services throughout Haiti. The CRHP approach to CHWs has served as a model for national CHW programming in India, both with the Village Health Guides program of the 1980s and the more recently established ASHA program. SEARCH's demonstration of the effectiveness of community–based management of pneumonia and of home–based neonatal care interventions stimulated further independent confirmatory research. Now, this approach has become the global standard of care around the world in resource–constrained settings, and its home–based neonatal care intervention has guided national replication and scale up by the government of India.

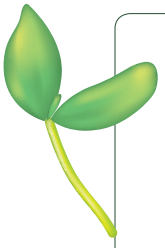
CONCLUSIONS

Although there is strong evidence that in highly controlled settings, specific interventions such as hand washing, vitamin A, immunizations and many others can improve child health, there is much less evidence for how health projects in high–mortality, resource–constrained settings can achieve long–lasting impacts on under–five mortality. The common characteristics of the four projects cited here give some important insights in considering this important question.

Most of the evidence regarding the effectiveness of community–based primary health care (CBPHC) in improving maternal, neonatal and chilld health (MNCH) outcomes comes from assessments of the effect of single interventions implemented in highly controlled and atypical field settings over a relatively short period of time, usually five years or less. The four projects identified and described here are the only four in our database of 700 assessments that have evidence of long–term impact of 10 years of more on mortality. The projects described here provide a comprehensive array of child health and maternal and reproductive health services, including family planning. They all provide general curative care, including hospital services, and they all facilitate referral and counter–referral services. Each project uses CHWs and provides strong training and support for them. Each also provides essential services for children in the home, has developed and sustained a high level of community engagement, and has earned the trust of the people it serves.

Each of these projects has used recurrently a cycle of consultation/planning, implementation, reflection/evaluation on a regular basis to adjust their projects to serve the needs of their local population. Over a long time, this process led to project characteristics that have been maintained. The similarity of these four projects' characteristics attests to the strength of this combination of project characteristics in serving its population's health needs.

Building strong and more comprehensive health systems in high–mortality, resource–constrained settings along the lines of the projects described here has the potential for not only long–term improvements in MNHC but also long–term improvements in control of HIV/AIDS, malaria and tuberculosis and even many emerging chronic conditions such as hypertension and diabetes. Learning to build and maintain these systems in a way so that they are affordable with local resources is one of our great challenges.



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REFERENCES

1 Perry HB, Rassekh B, Gupta S, Wilhelm J, Freeman P. A comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 1. rationale, methods and database description. J Glob Health. 2017;7:010901.

2 Bang AT, Bang RA, Reddy HM. Home-based neonatal care: summary and applications of the field trial in rural Gadchiroli, India (1993 to 2003). J Perinatol. 2005;25 Suppl 1:S108-22. Medline:15791272 doi:10.1038/sj.jp.7211278

3 Perry HB, Cayemittes M, Philippe F, Dowell D, Dortonne JR, Menager H, et al. Reducing under-five mortality through Hopital Albert Schweitzer's integrated system in Haiti. Health Policy Plan. 2006;21:217-30. Medline:16565151 doi:10.1093/heapol/czl005

4 Perry H, Berggren W, Berggren G, Dowell D, Menager H, Bottex E, et al. Long-term reductions in mortality among children under age 5 in rural Haiti: effects of a comprehensive health system in an impoverished setting. Am J Public Health. 2007;97:240-6. Medline:17194853 doi:10.2105/AJPH.2006.088732

5 Arole M, Arole R. Jamkhed - A Comprehensive Rural Health Project. London: Macmillan Press; 1994.

6 Chen LC, Rahman M, D'Souza S, Chakraborty J, Sardar AM, Yunus M. Mortality impact of an MCH-FP program in Matlab, Bangladesh. Stud Fam Plann. 1983;14:199-209. Medline:6636221 doi:10.2307/1966412

7 Razzaque A, Streatfield PK, Gwatkin DR. Does health intervention improve socioeconomic inequalities of neonatal, infant and child mortality? Evidence from Matlab, Bangladesh. Int J Equity Health. 2007;6:4. Medline:17547776 doi:10.1186/1475-9276-6-4

8 Hale L, DaVanzo J, Razzaque A, Rahman M. Why are infant and child mortality rates lower in the MCH-FP area of Matlab, Bangladesh? Stud Fam Plann. 2006;37:281-92. Medline:17209285 doi:10.1111/j.1728-4465.2006.00106.x

9 Aziz K. Mosley H. The History, Methodology, and Main Findings,of the Matlab Project in Bangladesh. In: Das Gupta M, Aaby P, Garenne M, Pison G, editors. Prospective community studies in developing countries International studies in demography. Oxford: Oxford University Press; 1997.

10 Fauveau V. Matlab: Women, Children and Health. Dhaka: International Centre for Diarrhoeal Disease Research, Bangladesh; 1994.

11 icddrb. Matlab and its impact on public health. 2016. Available: http://www.icddrb.org/research/platforms/field-sites/more-on-matlab. Accessed: 26 February 2017.

12 Perry HB. Health for All in Bangladesh: Lessons in Primary Health Care for the Twenty-First Century. Dhaka, Bangladesh: University Press Ltd; 2000.

13 Ali M, Emch M, Tofail F, Baqui AH. Implications of health care provision on acute lower respiratory infection mortality in Bangladeshi children. Soc Sci Med. 2001;52:267-77. Medline:11144783 doi:10.1016/S0277-9536(00)00120-9

14 Mostafa G, Ajmed K, Shaikh MAK, van Ginneken JH, Sarder AM. Demographic Surveillance System - Matlab. Volume 27. Registration of Vital Events - 1995. Dhaka: ICDDR.B.; 1996.

15 Mostafa G, Rahman MM. Demographic Surveillance System - Matlab. Volume 39. Registration of Health and Demographic Events - 2005. Dhaka: ICDDR.B.; 2007.

16 Rahman M, DaVanzo J, Razzaque A. The role of pregnancy outcomes in the maternal mortality rates of two areas in Matlab, Bangladesh. Int Perspect Sex Reprod Health. 2010;36:170-7. Medline:21245023 doi:10.1363/3617010

17 Fauveau V, Chakraborty J. Family Planning and Maternal and Child Health Services in Matlab. Fauveau V, editor. Dhaka: International Centre for Diarrheoal Disease Research, Bangladesh; 1994.

18 World Health Organization. UNICEF. Countdown to 2015 Decade Report (2000-2010) with Country Profiles: Taking Stock of Maternal, Newborn and Child Survival. Geneva: World Health Organization and UNICEF; 2010.

19 El Arifeen S, Christou A, Reichenbach L, Osman FA, Azad K, Islam KS, et al. Community-based approaches and partnerships: innovations in health-service delivery in Bangladesh. Lancet. 2013;382:2012-26. Medline:24268607 doi:10.1016/S0140-6736(13)62149-2

20 Schweitzer HA. Hôpital Albert Schweitzer. 2016. Available: http://www.hashaiti.org/. Accessed: 27 February 2017.

21 Berggren WL, Ewbank DC, Berggren GG. Reduction of mortality in rural Haiti through a primary-health-care program. N Engl J Med. 1981;304:1324-30. Medline:7219486 doi:10.1056/NEJM198105283042203

22 Berggren WL, Berggren GM. Changing incidence of fatal tetanus of the newborn. A retrospective study in a defined rural Haitian populations. Am J Trop Med Hyg. 1971;20:491-4. Medline:5088398 doi:10.4269/ajtmh.1971.20.491

23 Berggren WL. Control of neonatal tetanus in rural Haiti through the utilization of medical auxiliaries. Bull Pan Am Health Organ. 1974;8:24-9. Medline:4423926

24 Perry HB, Northrup R, Bryant J, Berggren W, Berggren G. The cost-effectiveness of a long-term comprehensive primary health care program in reducing under-5 mortality: findings from rural Haiti. J Epidemiol Community Health. Forthcoming 2017.

25 Victora CG, Requejo JH, Barros AJ, Berman P, Bhutta Z, Boerma T, et al. Countdown to 2015: a decade of tracking progress for maternal, newborn, and child survival. Lancet. 2016;387:2049-59. Medline:26477328 doi:10.1016/S0140-6736(15)00519-X

26 Jamkhed Comprehensive Rural Health Project. Comprehensive Rural Health Project Impact. 2016. Available: http://www.crhpjamkhed.org/impact/impact. Accessed: 27 February 2017.

27 Ministry of Health and Family Welfare GoI. Maharashtra: National Family Health Survey (NFHS-3), India, 2005-06. Mumbai, India: International Institute for Population Sciences; 2007. Available: http://www.nfhsindia.org/NFHS-3%20Data/Maharashtra_report.pdf. Accessed: 26 February 2017.

28 Mann V, Eble A, Frost C, Premkumar R, Boone P. Retrospective comparative evaluation of the lasting impact of a community-based primary health care programme on under-5 mortality in villages around Jamkhed, India. Bull World Health Organ. 2010;88:727-36. Medline:20931057 doi:10.2471/BLT.09.064469

29 McCord C, Premkumar R, Arole S, Arole R. Efficient and effective emergency obstetric care in a rural Indian community where most deliveries are at home. Int J Gynaecol Obstet. 2001;75:297-307, discussion 8-9. Medline:11728493 doi:10.1016/S0020-7292(01)00526-4

30 Newell KW, editor. Health by the People. Geneva: World Health Organization; 1975.

31 Arole M, Arole R. A comprehensive rural health project in Jamkhed (India). In: Newell KW, editor. Health by the People. Geneva, Switzerland: World Health Organization; 1975.

32 SEARCH. Society for Education, Action and Research in Community Health. 2016. Available: http://www.searchgadchiroli.org/. Accessed: 26 February 2017.

33 Dasgupta D. SEARCH: Society for Education, Action and Research in Community Health. Delhi: Voluntary Health Association of India; 1998.

34 Bang AT, Bang RA. Background of the field trial of home-based neonatal care in Gadchiroli, India. J Perinatol. 2005;25 Suppl 1:S3-10. Medline:15791276 doi:10.1038/sj.jp.7211267

35 Kielmann AA, Taylor CE, DeSweemer C, Parker RL. D. C, Reinke WA, et al. Volume 1. Child and Maternal Health Services in Rural India: the Narangwal Experiment. Integrated Nutrition and Health Care. Baltimore: Published for the World Bank [by] Johns Hopkins University Press; 1983.

36 Taylor CE, Sarma RSS, Parker RL, Reinke WA, Faruqee R. Volume 2. Child and Maternal Health Services in Rural India: the Narangwal Experiment. Integrated Family Planning and Health Care. Baltimore, MD: Johns Hopkins University Press; 1983.

37 Bang A, Bang R. Addiction as a barrier to development. In: Taylor-Ide D, Taylor C, editors. Just and Lasting Change: When Communities Own Their Futures. Baltimore: Johns Hopkins University Press; 2002.

38 Bang AT, Bang RA, Tale O, Sontakke P, Solanki J, Wargantiwar R, et al. Reduction in pneumonia mortality and total childhood mortality by means of community-based intervention trial in Gadchiroli, India. Lancet. 1990;336:201-6. Medline:1973770 doi:10.1016/0140-6736(90)91733-Q

39 Bang AT, Reddy HM, Deshmukh MD, Baitule SB, Bang RA. Neonatal and infant mortality in the ten years (1993 to 2003) of the Gadchiroli field trial: effect of home-based neonatal care. J Perinatol. 2005;25 Suppl 1:S92-107. Medline:15791283 doi:10.1038/sj.jp.7211277

40 Bang AT, Bang RA, Baitule SB, Reddy MH, Deshmukh MD. Effect of home-based neonatal care and management of sepsis on neonatal mortality: field trial in rural India. Lancet. 1999;354:1955-61. Medline:10622298 doi:10.1016/S0140-6736(99)03046-9

41 Perry H, Scott K, Javadi D, Gergen J, Shelley K, Crigler L, et al. Case Studies of Large-Scale Community Health Worker Programs: Examples from Afghanistan, Bangladesh, Brazil, Ethiopia, India, Indonesia, Iran, Nepal, Niger, Pakistan, Rwanda, Zambia, and Zimbabwe. 2017. Washington, DC: USAID/MCSP. Available: http://www.mcsprogram.org/wp-content/uploads/2017/01/CHW-CaseStudies-Globes.pdf. Accessed: 26 February 2017.

42 Wyon JB, Gordon JE. The Khanna Study: Population Problems in the Rural Punjab. Cambridge, MA: Harvard University Press; 1971.

Electronic supplementary material:
The online version of this article contains supplementary material.

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PAPERS

Comprehensive review of the evidence regarding the effectiveness of community–based primary health care in improving maternal, neonatal and child health: 8. summary and recommendations of the Expert Panel

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Background The contributions that community–based primary health care (CBPHC) and engaging with communities as valued partners can make to the improvement of maternal, neonatal and child health (MNCH) is not widely appreciated. This unfortunate reality is one of the reasons why so few priority countries failed to achieve the health–related Millennium Development Goals by 2015. This article provides a summary of a series of articles about the effectiveness of CBPHC in improving MNCH and offers recommendations from an Expert Panel for strengthening CBPHC that were formulated in 2008 and have been updated on the basis of more recent evidence.

Methods An Expert Panel convened to guide the review of the effectiveness of community–based primary health care (CBPHC). The Expert Panel met in 2008 in New York City with senior UNICEF staff. In 2016, following the completion of the review, the Panel considered the review's findings and made recommendations. The review consisted of an analysis of 661 unique reports, including 583 peer–reviewed journal articles, 12 books/monographs, 4 book chapters, and 72 reports from the gray literature. The analysis consisted of 700 assessments since 39 were analyzed twice (once for an assessment of improvements in neonatal and/or child health and once for an assessment in maternal health).

Results The Expert Panel recommends that CBPHC should be a priority for strengthening health systems, accelerating progress in achieving universal health coverage, and ending preventable child and maternal deaths. The Panel also recommends that expenditures for CBPHC be monitored against expenditures for primary health care facilities and hospitals and reflect the importance of CBPHC for averting mortality. Governments, government health programs, and NGOs should develop health systems that respect and value communities as full partners and work collaboratively with them in building and strengthening CBPHC programs – through engagement with planning, implementation (including the full use of community–level workers), and evaluation. CBPHC programs need to reach every community and household in order to achieve universal coverage of key evidence–based interventions that can be implemented in the community outside of health facilities and assure that those most in need are reached.

Conclusions Stronger CBPHC programs that foster community engagement/empowerment with the implementation of evidence–based interventions will be essential for achieving universal coverage of health services by 2030 (as called for by the Sustainable Development Goals recently adopted by the United Nations), ending preventable child and maternal deaths by 2030 (as called for by the World Health Organization, UNICEF, and many countries around the world), and eventually achieving Health for All as envisioned at the International Conference on Primary Health Care in 1978. Stronger CBPHC programs can also create entry points and synergies for expanding the coverage of family planning services as well as for accelerating progress in the detection and treatment of HIV/AIDS, tuberculosis, malaria, hypertension, and other chronic diseases. Continued strengthening of CBPHC programs based on rigorous ongoing operations research and evaluation will be required, and this evidence will be needed to guide national and international policies and programs.

This paper summarizes the current evidence regarding the effectiveness of community–based primary health care (CBPHC) in improving maternal, neonatal and child health (MNCH). It also proposes concrete steps to recognize that communities are a vital resource and key partners with health systems in improving MNCH.

We summarize here the findings presented in the earlier articles in this current series [1–7] and in the Reproductive, Maternal, Newborn and Child Health volume of the Disease Control Priorities, Third Edition [8,9]. It also is an outgrowth of the Working Group on CBPHC of the International Health Section of the American Public Health Association, and the papers of the Working Group prepared previously [10–12] as well as discussions of an Expert Panel (for membership see **Online Supplementary Document**) convened to guide the activities of the Working Group when the Panel met at UNICEF headquarters in New York City on 27–8 March 2008 with senior UNICEF staff along with senior staff from the World Health Organization (WHO) and the World Bank.

CBPHC is defined as a process by which health systems work with communities to improve health through activities that may be linked with health facilities but which take place in communities. The role of communities and community–based approaches to improving MNCH is still being overshadowed by the traditional "facility–centric" approach to health systems and calls for a new paradigm in which communities and community–based services are brought to the mainstream of health programs in order to improve the effectiveness of health systems in resource–constrained settings. Hybrid approaches also need to be developed in which professionalized CHWs divide their time by attending to patients at a village–based health post and visiting families in their homes, as is the case in Ethiopia.

The previous articles in this series provide an in–depth comprehensive review of evidence accumulated for over half a century regarding the effectiveness of community–based primary health care (CBPHC) in improving maternal, neonatal and child health (MNCH). The authors identified assessments of the health effects of community–based projects, programs and research studies (hereafter referred to as projects) in defined geographic populations. The review defines health effects broadly: change in (1) the population coverage of evidence–based interventions, (2) nutritional status, (3) serious morbidity, and (4) mortality. Not only did the authors assess health effects, but they also examined the equity of these projects as well as the strategies used to achieve health effects, including the common strategies of four projects identified that had evidence of mortality impact for 10 years or longer.

Why the review is important now

The era of the Millennium Development Goals (MDGs) ended in 2015 with only seven of 75 Countdown countries reaching the goal for maternal mortality and only one–third reaching the goal for mortality of children younger than five years of age [8]. The population coverage of 13 of 21 key evidence–based MNCH interventions is still less than 60% and for 6 of the 21 interventions it is less than 40% [8]. The second international *Countdown to 2015 Conference* met in Cape Town, South Africa, on 17–19 April 2008. The Call for Action arising from this Conference focused on the need for "long–term, predictable financing for strengthened health systems to deliver essential services to women, newborns and children," "dramatic scale–up of high–impact interventions," harmonization of donor support, and increased political commitment to health around the world [9]. However, there was no mention or call for building stronger partnerships with communities or strengthening CBPHC. Communities are the most undervalued resource in global health. Had communities been engaged more fully as partners with health systems, and had community–based primary health care been more fully developed, we believe there is a strong possibility that the MDG era might have ended very differently.

In 1948, the United Nations General Assembly affirmed in its Universal Declaration of Human Rights that everyone has a right to medical care and that "motherhood and childhood are entitled to special care and assistance" [13]. Forty years later, in 1978, the largest gathering of health officials convened up to that time by the World Health Organization and UNICEF affirmed at the International Conference on Primary Health Care that an acceptable level of health for all the people of the world could be achieved by the year 2000 through a fuller and better use of the world's resources (see **Box 1**) [15]. As the world seeks still to achieve these lofty goals, much work remains to be done. In 2015 the United Nations has adopted the Sustainable Development Goals, calling for a world *"free of poverty, hunger, disease and want, where all lives can thrive"* by the year 2030, with universal access to "*quality essential health–care services*" [16]. The World Health Organization and UNICEF have called for ending preventable child and maternal deaths in a generation [17,18]. However, even though recently released plans for achieving this goal do emphasize the importance of community engagement/empowerment, the critical and fundamental contribution of CBPHC to achieving this goal is muted [19,20].

Box 1. The Declaration of Alma Ata

"The people have the right and duty to participate individually and collectively in the planning and implementation of their health care" (Article V).

"Primary health care is essential health care based on practical, scientifically sound and socially acceptable methods and technology made universally accessible to individuals and families in the community through their full participation and at a cost that the community and country can afford to maintain at every stage of their development in the spirit of self–reliance and self–determination" (Article VI).

Primary health care "requires and promotes maximum community and individual self–reliance and participation in the planning, organization, operation and control of primary health care, making fullest use of local, national and other available resources; and to this end develops through appropriate education the ability of communities to participate" (Article VII) [14].

RESULTS

Specific interventions

Table 1 contains the evidence–based interventions that can be provided by community–level workers with appropriate training, supervision and support. All of these interventions are described in the review. The number of such interventions will certainly continue to grow with continued experience and operations research.

Equity

Although the equity of CBPHC services have not been studied as extensively as has overall intervention effectiveness, the available evidence supports a strong pro–equity effect of CBPHC interventions, as described in more detail in Paper 5 of this series [5]. The term pro–equity effect signifies that the most disadvantaged segment of the population, usually defined in terms of income quintiles or some other type of socio–economic status, benefit more from the delivery of one or more CBPHC interventions than does

Table 1. Effective interventions for maternal, newborn and child health that can be provided by community health workers in the community or at a health post [21–23]

Point in continuum of care				
Pregnancy	**Delivery (normal)**	**Postpartum (woman)**	**Postpartum (newborn)**	**Child**
Preparation for safe birth and newborn care; emergency planning	Management of labor and delivery and referral of complications	Promotion of breastfeeding	Neonatal resuscitation	Promote breastfeeding and complementary feeding
Micronutrient supplementation*			Breastfeeding	Provide vitamin A, zinc, and food supplementation
Nutrition education			Thermal care for preterm newborns	Immunizations
Intermittent preventive treatment of malaria during pregnancy)			Promote care–seeking	Co–trimoxazole for HIV–positive children
Food supplementation			Assess for danger signs and refer	Education on safe disposal of children's stools and handwashing
Promotion of HIV testing			Oral antibiotics for pneumonia	Distribute and promote use of ITNs† or IRS‡, or both
				Assess for danger signs and refer
				Detect and refer children with severe acute malnutrition
				Detect and treat serious infections without danger signs (iCCM§), refer if danger signs present

*Because of some evidence of risk and gaps in the evidence, the WHO does not at this time recommend multiple micronutrient supplementation for pregnant women to improve maternal and perinatal outcomes [24].
†Insecticide–treated bednet.
‡Indoor residual spraying.
§Integrated community case management (the components include treatments for diarrhea, pneumonia, malaria).

the better–off segment of the population. Community–based approaches can reach those furthest from health facilities and can rapidly expand population coverage of key interventions, so these findings are not surprising. These findings stand in stark contrast to the commonly observed finding that utilization of primary health care facilities is inequitable because those in the lower income quintiles are less likely to obtain services there [25,26]. This evidence together with the lack of evidence that investments in facilities alone can improve population health in resource–constrained settings [27,28] provide additional support for the importance of investing in CBPHC for improving MNCH.

Strategies for achieving effectiveness

The projects included in the review utilized myriad innovative approaches for working in partnership with communities and with health systems for making CBPHC interventions effective in improving MNCH. These are described in greater detail in paper 4 in this series [6]. Clearly no one size fits all situations, and contextual considerations have a major influence on project operations. Nevertheless, important themes emerged from the review. Many project assessments described engagement with community leaders (both formal and informal), engagement with existing and/or formation of new women's groups, and devising innovative ways to share key education messages with the community (through skits, songs, stories, games and peer–to–peer education). Community–level workers of many types (including both volunteer and paid workers) assisted with project implementation. In most cases, these workers were women, and in three–quarters of the projects included in the review some type of training was provided to these workers. In more than half the projects assessed the community was involved in project implementation, promotion of partnerships between the project and the community, promotion of the use of local resources, and promotion of community engagement/empowerment. In nearly half of the projects, promotion of women's empowerment was present. In approximately 39% of the projects, communities were involved in planning the project and in 40% they were involved in the evaluation.

Many projects engaged in health system strengthening activities of various types, including training of staff based at peripheral health facilities who supervise community–level activities and treat referred patients, strengthening the supervisory system of community–level workers and the logistics/drug supply system for both the peripheral health facility and the community–level workers, and strengthening the referral system. Building strong links among the community–level activities, the peripheral health facility and the referral hospital were common features of effective projects.

Finally, four implementation intervention strategies were commonly encountered. First, home visitations, often routine visits to all homes as well as visits to targeted groups, were often carried out by both volunteer and paid community–level workers. Second, these workers commonly provided community case management, in which they provided education on warning and dangers signs, identified cases in need of referral, and/or treated cases in the community with appropriate medications. A third strategy identified among the projects included in the assessments was the formation of participatory women's groups in which groups of women meet with a facilitator to learn about ways in which they can promote their own health and the health of their children and share this information in their community. The process not only improves the health of mothers and children but it empowers women at the same time. A fourth implementation strategy identified is the provision of community–based services by mobile teams based a peripheral health facilities. These four strategies are not mutually exclusive, of course.

Of the 700 assessments, only four had evidence of mortality impact of 10 years or more, but their common features are striking: they all provided a comprehensive set of primary health care services, including family planning; they had a strong community health worker program that maintained regular contact with all households; they all had strong collaborations with the communities they serve; and they all had strong referral capabilities and provided first–level hospital care.

Limitations of the evidence identified

Although the evidence is extensive, it does have important limitations that need to be recognized. First of all, the evidence is largely limited to assessments of a small number of interventions implemented over a relatively short period of time (2–3 years) in highly controlled field settings with a relatively small population (only 11% of the projects assessed served more than 25 000 women and children), and almost half (46%) of the projects were implemented over a period of 1 year or less and with only 13% implemented over a period of 5 or more years. Thus, the evidence for effectiveness of more comprehensive programs that reach larger populations over longer periods of time is limited.

There is a notable lack of evidence regarding failed attempts to improve MNCH through CBPHC. Publication bias needs to be recognized, and the overall findings interpreted accordingly. But more importantly, more analyses are needed of the main barriers that hinder the fuller development of CBPHC to improve MNCH and steps that need to be taken to overcome them. Furthermore, more attention needs to be given to the puzzling question of why, given the overwhelming evidence, more effort has not been given to strengthening and scaling up CBPHC, especially in countries with a high burden of maternal, neonatal and child mortality. Ghana is a case in point, where an effective evidence–based CBPHC approach [29] reached only 8% national coverage over an 8–year period as a result of inadequate financial backing and donor support [30,31].

We make no claim that this is a systematic review of the evidence. We do claim that it is a comprehensive review of the evidence. The presence of an *a priori* design, the inclusion of gray literature, the listing of included articles, the presence of a quality assessment of included reviews and incorporation of this into conclusions of individual articles, and the inclusion of conflict of interest and funding information for the entire review allow the review to meet 7 of the 11 quality AMSTAR criteria for judging the quality of a systematic review [32].

Given the broad scope and heterogeneity of the evidence included, by necessity the review is largely descriptive and does not undertake a quantitative analysis of effect strength of specific interventions or packages of interventions. This limits the power of conclusions that pertain to specific interventions. Nonetheless, the main finding of the review, namely that CBPHC is an effective and essential approach for improving MNCH, is not lost by dwelling on detailed discussions of which specific interventions or which packages of interventions are most important. We know that new interventions will continually be introduced in the future, and epidemiological as well contextual conditions will change over time, so keeping a focus on CBPHC as a strategy for implementing specific interventions, which this review attempts to do, is important.

Strengths of the review

The review described in this series has some important strengths. First, it is one of the most comprehensive in–depth current reviews on this important topic that is highly relevant for accelerating progress in reducing 6 million deaths of mothers and their offspring each year [8,9], most of which are from readily preventable or treatable conditions. While the effectiveness of many of the interventions described here is well–known, the breadth of interventions known to be effective is less well–known, as are the most common strategies used to implement them. The reviewers included evidence not only from the peer–reviewed literature but also from unpublished project evaluations, books, and reports from the gray literature. The review is composed of 700 assessments. Second, it is one of the most comprehensive reviews currently available, with great efforts taken to extract all available information about how each project included in the review was implemented, how communities were engaged, how interventions were delivered at the community level, and what steps were taken to strengthen the health system.

Estimates of the number of lives of mothers and their children that could be saved by scaling up CBPHC

Long–standing experience and rapidly growing evidence both show that simplified home– and community–based interventions can be remarkably effective in expanding the coverage of evidence–based interventions and reducing maternal, neonatal and child mortality [22,23]. The best current evidence indicates that if the complete package of evidence–based interventions for mothers and their children that can be provided at the community level reach all who need them, 2.3 million deaths would be averted each year compared to the interventions that require delivery in primary health care centers (which would avert 0.8 million deaths) and in hospitals (which would avert 0.9 million deaths) (**Figure 1**) [22].

Promoting community engagement/empowerment

Promoting community engagement/empowerment to increase intervention effectiveness is obviously not simple, but major progress has been documented [33]. Experience shows that the following questions must be addressed by both programs and communities:

- Will the community be a participating partner and bring its own considerable resources (mostly non–financial) to improve MNCH, or will the more common practices continue of health systems considering communities mainly as targets and essentially passive recipients of services?

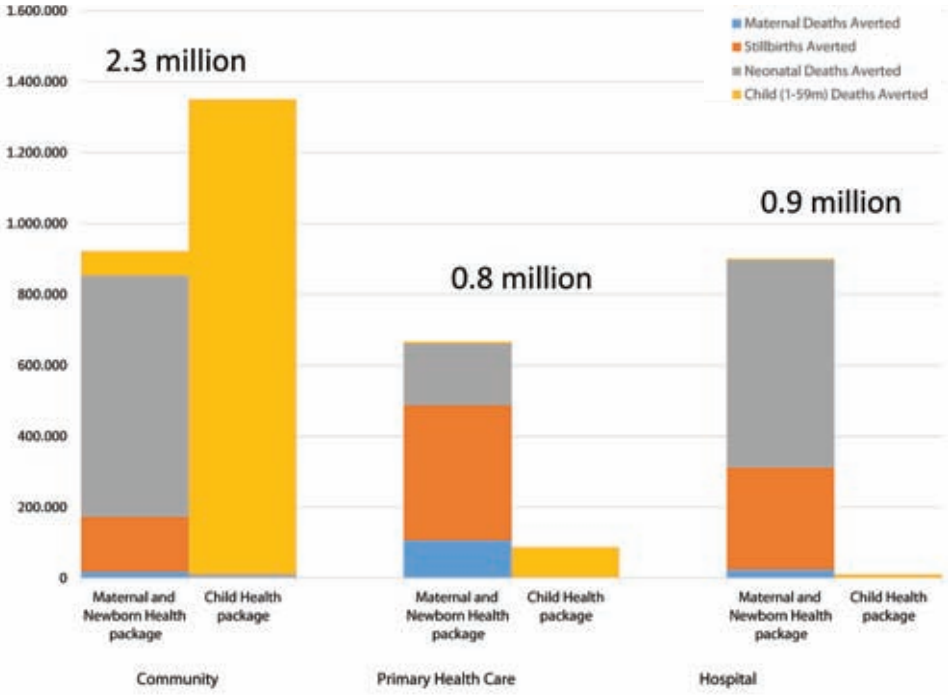


Figure 1. Maternal, perinatal, neonatal and child deaths that can be averted by health–care packages through three service platforms [22]. The numbers above the columns were not in the original figure. The services assumed to be provided in each platform are as follows. ***The community platform:*** all interventions that can be delivered by a community–based health worker with appropriate training and support or by outreach services, such as child health days, immunizations, vitamin A, and other interventions. ***The primary health center (PHC) platform:*** a facility with a doctor or a nurse midwife (or both), nurses and support staff, as well as both diagnostic and treatment capabilities. The PHC provides facility–based contraceptive services, including long–acting reversible contraceptives (implants, intrauterine devices); surgical sterilization (vasectomy, tubal ligation); care during pregnancy and delivery for uncomplicated pregnancies; provision of medical care for adults and children, such as injectable antibiotics, that cannot be done in the community; and training and supervision of community–based workers. ***The hospital platform:*** consisting of both first–level and referral hospitals, includes more advanced services for management of labor and delivery in high–risk women or those with complications, including operative delivery, full supportive care for preterm newborns, and care of children with severe infection or severe acute malnutrition with infection [22].

- Will the community have the opportunity to participate in setting priorities as well as implementing and evaluating program activities, in contrast to the much more common practice of health professionals defining these roles as the responsibility of the health system?

Although the Expert Panel did not approach these questions as either–or alternatives, it did view community engagement/empowerment as important for enabling the delivery system to more effectively improve MNCH.

Activities that communities can contribute to improving the effectiveness of interventions and that can be empowering for communities include the following:

- Involving local leadership in mobilizing the community for planning and management of activities (including the management of external resources);
- Clarifying local value systems to help both the delivery system and community develop mutual understanding and respect as they work together for results that are effective and equitable;
- Involving women's groups in participatory learning and action, peer–to–peer education, and provision of home–based care;
- Involving men and mothers–in–law in creative ways that encourage healthy behaviors and appropriate health care utilization;
- Participating in adapting the delivery system to local realities and local culture with integration of interventions for acceptability and efficiency;
- Participating in monitoring, evaluation and accountability; and,

- Collaborating not just in a series of interventions during the initial stages of implementation but establishing long–term partnerships for robust and sustainable systems.

Effective program planning, implementation and assessment require community involvement, and the evidence is clearest for home–based neonatal care and community–based management of childhood diarrhea, pneumonia and malaria. For other interventions (eg, immunizations), community engagement/empowerment is important to ensure that children who need an intervention are taken to where they can receive it (or to take the intervention to where the child is, ie, in the home). CBPHC requires linkages with facilities. Populations with the most limited access to formal health care are typically in the most unreached areas where mortality is the highest and therefore where impact can be greatest. Here also equity issues are central. The nature of effective partnerships between health intervention delivery systems and communities vary greatly as a result of the need to adapt them to the local context [34]. Supportive environments for CBPHC and community engagement/empowerment at local, national, international and global levels are now needed, especially as the evidence of effectiveness continues to grow. Community–level workers providing CBPHC have been shown to be effective in improving not only MNCH in low–income countries but also in improving health priorities in middle– and upper–income countries as well [35,36].

Scaling up community–based primary health care

The evidence for the effectiveness of CBPHC in improving MNCH at scale is still limited. Yet, encouraging national examples of improvement in MNCH exist in countries such as Afghanistan, Brazil, Ethiopia, Nepal and Rwanda [37,38] and these countries have established strong CBPHC programs that have made a major contribution to these achievements. More research is needed to fully assess the contribution that strengthened CBPHC has made to these achievements.

Innovative approaches to scaling up CBPHC approaches that improve MNCH are needed. Some examples are the following:

- Establishment of a cadre of government–authorized community–level workers throughout the country with gradual addition of responsibilities, as has happened in Afghanistan, Brazil, Bangladesh, Ethiopia, India, Malawi, Nepal, Niger, Rwanda, and many other countries [38];
- The gradual expansion of a package of interventions to national level beginning with a small effective program implemented by one NGO, replication by other NGOs, with gradual transfer of the intervention into the government system as is currently underway in India, as has occurred for home–based neonatal care, beginning with SEARCH's pioneering work in Gadchiroli [39];
- "Scaling down to scale up" in which a documented successful approach is replicated at other sites with strong local input and flexibility, allowing local champions to emerge, as has been carried out by the Navrongo Initiative working through the Ministry of Health in Ghana [29];
- A three–way partnership at the outset for scaling up, in which the community, government officials, and an outside agent (such as an NGO or technical support group) first establishes model program sites as nodes to adapt and systematize extension to larger populations, as was done in China with the Model Counties Project [40] (which has now become China's rural MCH system) and as Future Generations has done with its SEED–SCALE approach to improve the health of children in Arunachal Pradesh (India); Tibet (China), Afghanistan and Peru [41];
- A "bottom–up" educational approach to scaling up, in which grassroots workers from many geographic areas and programs in different countries come to a central training center to learn empowerment and CBPHC, as is occurring at the Comprehensive Rural Health Program (CRHP) in Jamkhed, India, where more than 30 000 people from around India and more than 3000 people from 100 other countries have now been trained [42];
- Creation of a national framework giving local communities the option of establishing shared control over health centers and local programs, as has occurred in Peru's program of *Communidades Locales para la Administracion de Salud* (CLAS), under which one–third of the government's 2400 health centers are now governed [43]; and,
- The gradual expansion of one key intervention to a national level under the direction of a single NGO, as was carried out by BRAC through its home–based training of mothers to prevent and treat childhood diarrhea [44].

There is a need to test different approaches for rapid scaling up so that CBPHC programs can achieve national impact more rapidly. Even though "command and control" approaches can be used for scaling up

standardized components of community–based interventions, in most poor countries such approaches have been supported by external donors for only a limited time period, producing initial successes that cannot be sustained after external funding ends. By contrast, new systematic processes need to be developed that can adapt to local realities in ways that promote community engagement/empowerment and long–term local sustainability [25]. Different approaches to scaling up should be tested through monitoring of quality and coverage as well as through rigorous implementation research. This would enhance the potential for greater effectiveness and long–term sustainability without over–dependence on central or international funding.

The limited evidence of effectiveness of a broad package of CBPHC interventions over a period of more than 3 years at scale is a serious concern. Long–term field studies to assess the ongoing effectiveness of a comprehensive package of CBPHC interventions are needed to enable such programs to continually improve their effectiveness and to provide guidance for similar programs. The strengthening and scaling up of effective CBPHC programs is a long–term process that will require continuing adjustment as conditions and contexts change, and as new evidence-based interventions become available. Efficiencies and final aspects of CBPHC are not adequately address in the literature. Thus, investments in long–term implementation research are greatly needed.

Specific recommendations of the Expert Panel

The Expert Panel calls for the following steps.

1. CBPHC should be a priority for strengthening health systems, for accelerating progress in achieving universal health coverage, and for ending preventable child and maternal deaths.
2. The amount of resources devoted to CBPHC should be tracked at national and regional levels, and attention should be given by policy makers and political leaders to ensure that funding for CBPHC is expanding appropriately.
3. Communities are an undervalued resource, and their full participation and partnership needs to be fostered in order for CBPHC to reach its full potential. Building partnerships between health systems and communities is essential in order to reach those most in need with effective, equitable, and sustainable programs.
4. Prioritization should be given to strengthening CBPHC in populations with the highest mortality in order to achieve greater impact.
5. A strong CBPHC service delivery platform should be established not only for accelerating progress in improving MNCH and child development but also for reducing the unmet need for family planning, for ending the HIV/AIDS epidemic, controlling malaria, tuberculosis, and priority non–communicable diseases such as hypertension, diabetes and mental illness, and for surveillance (identification of infectious disease outbreaks and registration of vital events). The establishment of the CBHC service delivery platform for MNCH is urgent, while the inclusion of other elements will need to be a gradual and longer–term process. A strong CBPHC service delivery system will make it possible to incorporate new interventions as they are developed, and such a system will be needed for the long term, even after ending preventable child and maternal deaths and achieving universal coverage of health services. Such a system will be needed, in fact, for eventually reaching universal comprehensive health coverage and Health for All.
6. Future progress in improving the effectiveness of CBPHC for MNCH will require an expanded research agenda to continually advance the contextualized evidence on CBPHC program effectiveness at scale over a longer period of time with multiple evidence–based interventions. Adequate financial support for advancing the evidence base for CBPHC program effectiveness will be essential if CBPHC programs are to fulfill their potential.

Table 2 and **Table 3** provide additional detailed to the recommendations of the Expert Panel for promoting community engagement/empowerment and for strengthening health systems that will make it possible for CBPHC to more effectively reduce maternal, neonatal and child mortality.

Reaching the unreached and most vulnerable members of our global family – namely mothers and children – through CBPHC was the vision of the three global health pioneers – Carl Taylor (founder of the Department of International Health at Johns Hopkins and Chair of the Expert Panel prior to his death in 2010), Jim Grant (Executive Director of UNICEF from 1980 to 1995) and Halfdan Mahler (Director General of WHO from 1973–1988). They all provided leadership for the International Conference on Primary Health Care at Alma–Ata in 1978 and its Declaration of Alma–Ata and worked tirelessly to achieve

Table 2. Expert Panel recommendations for promoting community engagement/empowerment for improved maternal, neonatal and child health

Main recommendations	Details
Empower communities and women in these communities to be more actively engaged in improving the health of mothers, newborns and children	Establish a foundation of values that supports partnerships with communities and processes to build community capacity through giving communities a voice in supervising or controlling certain aspects of local government health services, and through building the agency of women (such as the promotion of women's empowerment, support of micro–credit programs and development of conditional cash transfer programs).
	Support the development of community–based organizations focused on local health needs and on the planning, implementation, and evaluation of local health programs.
Build stronger partnerships between the community and the health system	Create a health system culture that is respectful of and collaborative with community members.
	Create bi–directional communication flows.
	Create bi–directional linkages between the district health system and communities that can help everyone be accountable for health system performance.
Involve communities in monitoring, evaluation, and use of health–related information	Create systems for the community's generation and use of health data (including registration of births and deaths and identification of those in greatest need of services, as part of a continuing process to promote equity in all stages of health care).
	Develop participatory approaches to the monitoring and evaluation of CBPHC programs, including assessments of mortality impact.

Table 3. Expert Panel recommendations for strengthening the delivery system for improved maternal, neonatal and child health

Main recommendations	Details
Extend the delivery system to every community and household	Involve community members in the delivery of services.
	Train and support community–level workers who (1) receive sufficient incentives or salary to support their long–term involvement, (2) receive appropriate supportive and technical supervision from staff based at the nearest health facility, and (3) are accountable to their local community.
	Provide appropriate training and supervision of community–level workers (who preferably are selected from and by the communities where they will work) to perform health tasks that respond to local health needs and that address the epidemiological priorities of mothers and their children.
	Train and support neighborhood volunteers for peer–to–peer health promotion.
	Develop an appropriate balance of community–level workers for the required service intensity (while at the same time ensuring a suitable workload for an appropriate number of tasks and ensuring enough time required for each task, given the distance to homes and the level of remuneration/ incentives).
	Coordinate the activities of the formal health sector with the informal health sector (drug sellers and individual practitioners, including traditional healers).
Promote delivery of interventions to those at greatest risk	Provide "safety nets" that reduce barriers to accessing and providing services (eg, "CBPHC–friendly" insurance systems to remunerate providers and incentive schemes to promote utilization of health services).
	Create equitable service delivery strategies that identify and reach those in greatest need
Build a stronger, more efficient, and more effective health delivery system	Provide adequate, sustainable and flexible global, national and local financing that responds to the needs of community–based programs in relation to the amount being spent for facility–based care.
	Foster investments at the community and local level for support of community–based programs and for strengthening primary health care at peripheral health facilities.
	Provide adequate supplies for service delivery.
	Integrate services at the community level (based on delivery system capacity and local need).
	Monitor expenditures for CBPHC against those for primary health centers and hospitals and ensure that these levels are appropriate given the importance of CBPHC for averting deaths.

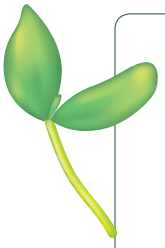
that vision, which remains unfilled. They recognized, and the Declaration of Alma–Ata affirms, that health care needs to be brought "as close as possible to where people live and work" and that this requires health workers at all levels, including *"physicians, nurses, midwives, auxiliaries and community workers as applicable"* [14]. Over the past three decades, the evidence of what can be achieved through CBPHC to improve the health of mothers, neonates and children has grown exponentially.

However, CBPHC still remains, as El–Saharty and colleagues rightly calls it, an "unfunded afterthought" [45] (p. 270) rather than the solid foundation of effective health systems. Jim Grant repeatedly reminded us that "morality must march with changing capacity" [46]. And Halfdan Mahler reminded the world in his 2008 address to the 61st World Health Assembly, "unless we all become partisans in the renewed local and global battles for social and economic equity in the spirit of distributive justice, we shall indeed betray the future of our children and grandchildren" [47]. Establishing the political will to fund and build strong CBPHC programs is urgently needed, as is defining the resource needs so that these programs will not remain an "unfunded afterthought."

Carl Taylor, in his final publication, wrote that "[r]eal social change occurs when officials and people with relevant knowledge and resources come together with communities in joint action around mutual priorities" [34]. The evidence confirms the promise of CBPHC in ending preventable maternal, neonatal and child deaths. Building on this evidence and making CBPHC the priority that it needs to be is one of the great challenges for global health in the 21st century and one of the giant steps that can be taken to eventually achieve Health for All.

CONCLUSIONS

Stronger CBPHC programs that foster community engagement/empowerment and implement evidence–based interventions will be essential for achieving universal coverage of health services by 2030 (as called for by the Sustainable Development Goals recently adopted by the United Nations) [48]), ending preventable child and maternal deaths by 2030 (as called for by the World Health Organization, UNICEF and many other countries) [17], and eventually achieving Health for All as initially envisioned in 1978 at the International Conference on Primary Health Care convened by WHO and UNICEF [14]. Stronger CBPHC programs will create entry points and synergies for expanding the coverage of family planning services [49] and for accelerating progress in the detection and treatment of HIV/AIDS [50], tuberculosis [51] malaria [52], and hypertension and other chronic diseases [53]. International cooperation will be important in promoting stronger CBPHC implementation world–wide. Advocacy at global, international, national and local levels, exchange of information and experiences, training, and evaluations of program implementation will all contribute to stronger CBPHC programming. Specific mechanisms need to be developed through which we can more effectively learn from experience and generate evidence to guide local, national and international policies and programs.



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1 Perry H, Rassekh B, Gupta S, Wilhelm J, Freeman P. Comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 1. rationale, methods and database description. J Glob Health. 2017;7:010901.

2 Jennings M, Pradhan S, Schleiff M, Sacks E, Freeman P, Gupta S, et al. Comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 2. maternal health findings. J Glob Health. 2017;7:010902.

3 Sacks E, Freeman P, Sakyi K, Jennings M, Rassekh B, Gupta S, et al. Comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 3. neonatal health findings. J Glob Health. 2017;7:010902.

4 Freeman P, Schleiff M, Sacks E, Rassekh B, Gupta S, Perry H. Comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 4. child health findings. J Glob Health. 2017;7:010904.

5 Schleiff M, Kumapley R, Freeman P, Gupta S, Rassekh B, Perry H. Comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 5. equity effects. J Glob Health. 2017;7:010905.

6 Perry H, Rassekh B, Gupta S, Freeman P. Comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 6. strategies used by effective projects. J Glob Health. 2017;7:010906.

7 Perry H, Rassekh B, Gupta S, Freeman P. Comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 7. programs with evidence of long-term impact on mortality in children younger than five years of age. J Glob Health. 2017;7:010907.

8 Victora CG, Requejo JH, Barros AJ, Berman P, Bhutta Z, Boerma T, et al. Countdown to 2015: a decade of tracking progress for maternal, newborn, and child survival. Lancet. 2016;387:2049-59. Medline:26477328 doi:10.1016/S0140-6736(15)00519-X

9 UNICEF. Tracking Progress in Maternal, Newborn and Child Survival. The 2008 Report. 2008. Available: http://www.who.int/pmnch/Countdownto2015FINALREPORT-apr7.pdf. Accessed: 26 February 2017.

10 Perry H, Freeman P, Gupta S, Rassekh B. How Effective Is Community-based Primary Health Care in Improving the Health of Children? Summary Findings and Report to the Expert Review Panel: American Public Health Association; 2009. Available: http://www.coregroup.org/storage/documents/finalcbphcreport_july2009.pdf and http://aimdb.files.wordpress.com/2009/08/finalcbphcreporttoerp-7july2009.pdf. Accessed: 26 February 2017.

11 Perry H, Freeman P, Gupta S, Rassekh B. Building on the Current Evidence to Strengthen Community-Based Service Delivery Strategies for Promoting Child Survival. 2010. Available: http://www.mchip.net/sites/default/files/USAID%20CBPHC%20FINAL.pdf. Accessed: 26 February 2017.

12 Freeman P, Perry HB, Gupta SK, Rassekh B. Accelerating progress in achieving the millennium development goal for children through community-based approaches. Glob Public Health. 2012;7:400-19. Medline:19890758 doi:10.1080/17441690903330305

13 United Nations General Assembly. Universal Declaration of Human Rights. 1948. Available: http://www.ohchr.org/EN/UDHR/Documents/UDHR_Translations/eng.pdf. Accessed: 26 February 2017.

14 World Health Organization. UNICEF. Declaration of Alma-Ata: International Conference on Primary Health Care. 1978. Available: http://www.who.int/publications/almaata_declaration_en.pdf. Accessed: 27 February 2017.

15 World Health Organization. UNICEF, editors. Declaration of Alma-Ata. International Conference on Primary Health Care, 6-12 September 1978; 1978; Alma-Ata, USSR. Geneva, Switzerland: World Health Organization; 1978.

16 UN. Sustainable Development Goals. 2015. Available: https://sustainabledevelopment.un.org/topics/sustainabledevelopmentgoals. Accessed: 26 April 2017.

17 Chan M, Lake A. Towards ending preventable child deaths. Lancet. 2012;379:2119-20. Medline:22682447 doi:10.1016/S0140-6736(12)60908-8

18 Glass RI, Guttmacher AE, Black RE. Ending preventable child death in a generation. JAMA. 2012;308:141-2. Medline:22695930 doi:10.1001/jama.2012.7357

19 USAID. Acting on the Call: Ending Preventable Child and Maternal Deaths: A Focus on Equity. 2016. Available: https://www.usaid.gov/sites/default/files/Final-AOTC-file-v2.pdf. Accessed: 26 April 2017.

20 World Health Organization. The Global Strategy for Women's, Children's and Adolescents' Health (2016-2030): Survive, Thrive, Transform. 2016. Available: http://www.who.int/pmnch/media/events/2015/gs_2016_30.pdf. Accessed: 26 April 2017.

21 Black R, Walker N, Laxminarayan R, Temmerman M. Reproductive, Maternal, Newborn, and Child Health: Key Messages of This Volume. In: Black R, Laxminarayan R, Temmerman M, Walker N, editors. Reproductive, Maternal, Newborn, and Child Health. Washington, DC: World Bank; 2016.

22 Black RE, Levin C, Walker N, Chou D, Liu L, Temmerman M, et al. Reproductive, maternal, newborn, and child health: key messages from Disease Control Priorities 3rd Edition. Lancet. 2016;388:2811-24.

23 Lassi ZS, Kumar R, Bhutta ZA. Community-based care to improve maternal, newborn, and child health. 2016. In: Disease Control Priorities: Reproductive, Maternal, Newborn, and Child Health, Third Edition. Washington, DC: World Bank. Available: https://openknowledge.worldbank.org/bitstream/handle/10986/23833/9781464803482.pdf?sequence=3&isAllowed=y. Accessed: 26 February 2017.

24 World Health Organization. Multiple micronutrient supplementation during pregnancy. 2017. Available: http://www.who.int/elena/titles/micronutrients_pregnancy/en/. Accessed: 27 February 2017.

25 Szwarcwald CL, Souza-Junior PR, Damacena GN. Socioeconomic inequalities in the use of outpatient services in Brazil according to health care need: evidence from the World Health Survey. BMC Health Serv Res. 2010;10:217. Medline:20653970 doi:10.1186/1472-6963-10-217

26 Malik SM, Ashraf N. Equity in the use of public services for mother and newborn child health care in Pakistan: a utilization incidence analysis. Int J Equity Health. 2016;15:120. Medline:27459961 doi:10.1186/s12939-016-0405-x

27 Baqui AH, El-Arifeen S, Darmstadt GL, Ahmed S, Williams EK, Seraji HR, et al. Effect of community-based newborn-care intervention package implemented through two service-delivery strategies in Sylhet district, Bangladesh: a cluster-randomised controlled trial. Lancet. 2008;371:1936-44. Medline:18539225 doi:10.1016/S0140-6736(08)60835-1

28 Bryce J, Victora CG. Ten methodological lessons from the multi-country evaluation of integrated Management of Childhood Illness. Health Policy Plan. 2005;20 Suppl 1:i94-105. Medline:16306075 doi:10.1093/heapol/czi056

29 Nyonator FK, Awoonor-Williams JK, Phillips JF, Jones TC, Miller RA. The Ghana community-based health planning and services initiative for scaling up service delivery innovation. Health Policy Plan. 2005;20:25-34. Medline:15689427 doi:10.1093/heapol/czi003

30 Krumholz AR, Stone AE, Dalaba MA, Phillips JF, Adongo PB. Factors facilitating and constraining the scaling up of an evidence-based strategy of community-based primary care: management perspectives from northern Ghana. Glob Public Health. 2015;10:366-78. Medline:25436901 doi:10.1080/17441692.2014.981831

31 Awoonor-Williams JK, Phillips JF, Bawah AA. Catalyzing the scale-up of community-based primary healthcare in a rural impoverished region of northern Ghana. Int J Health Plann Manage. 2016;31:e273-89. Medline:26189569 doi:10.1002/hpm.2304

32 Shea BJ, Grimshaw JM, Wells GA, Boers M, Andersson N, Hamel C, et al. Development of AMSTAR: a measurement tool to assess the methodological quality of systematic reviews. BMC Med Res Methodol. 2007;7:10. Medline:17302989 doi:10.1186/1471-2288-7-10

33 Rosato M, Laverack G, Grabman LH, Tripathy P, Nair N, Mwansambo C, et al. Community participation: lessons for maternal, newborn, and child health. Lancet. 2008;372:962-71. Medline:18790319 doi:10.1016/S0140-6736(08)61406-3

34 Taylor CE. What would Jim Grant say now? Lancet. 2010;375:1236-7. Medline:20382313 doi:10.1016/S0140-6736(10)60449-7

35 Perry HB, Zulliger R, Rogers MM. Community Health Workers in low-, middle-, and high-income countries: an overview of their history, recent evolution, and current effectiveness. Annu Rev Public Health. 2014;35:399-421. Medline:24387091 doi:10.1146/annurev-publhealth-032013-182354

36 Hannay J, Heroux J. Community Health Workers and a Culture of Health: Lessons from U.S. and Global Models - A Learning Report. 2016. Available: http://www.rwjf.org/en/library/research/2016/08/community-health-workers-and-a-culture-of-health–lessons-from-u.html. Accessed: 27 February 2017.

37 El Arifeen S, Christou A, Reichenbach L, Osman FA, Azad K, Islam KS, et al. Community-based approaches and partnerships: innovations in health-service delivery in Bangladesh. Lancet. 2013;382:2012-26. Medline:24268607 doi:10.1016/S0140-6736(13)62149-2

38 Perry H, Scott K, Javadi D, Gergen J, Shelley K, Crigler L, et al. Case Studies of Large-Scale Community Health Worker Programs: Examples from Afghanistan, Bangladesh, Brazil, Ethiopia, India, Indonesia, Iran, Nepal, Niger, Pakistan, Rwanda, Zambia, and Zimbabwe. 2017. Washington, DC: USAID/MCSP. Available: http://www.mcsprogram.org/wp-content/uploads/2017/01/CHW-CaseStudies-Globes.pdf. Accessed: 26 February 2017.

39 Bang AT, Bang RA, Reddy HM. Home-based neonatal care: summary and applications of the field trial in rural Gadchiroli, India (1993 to 2003). J Perinatol. 2005;25 Suppl 1:S108-22. Medline:15791272 doi:10.1038/sj.jp.7211278

40 Taylor C, Parker R, DongLu D. China's model counties: Going to scale with health care. In: Taylor-Ide D, Taylor CE, editors. Just and Lasting Change: When Communities Own Their Futures. Baltimore and London: Johns Hopkins University Press; 2002. p. 284-95.

41 Taylor-Ide D, Taylor C. How to go to scale. In: Taylor-Ide D, Taylor CE, editors. Just and Lasting Change: When Communities Own Their Futures. Baltimore and London: Johns Hopkins University Press; 2002.

42 Arole M, Arole R. Jamkhed, India: The Evolution of a World Training Center. In: Taylor-Ide D, Taylor C, editors. Just and Lasting Change: When Communities Own Their Futures. Baltimore: Johns Hopkins University Press; 2002.

43 Paredes P, Taylor CE. Peru: Communities and Government Learning to Work Together. In: Taylor-Ide D, Taylor CE, editors. Just and Lasting Change: When Communities Own Their Futures. Baltimore and London: Johns Hopkins University Press; 2002.

44 Chowdhury AMR, Cash RA. A Simple Solution: Teaching Millions to Treat Diarrhoea at Home. Dhaka, Bangladesh: University Press Limited; 1996.

45 El-Saharty S, Janovsky K, Siadat B, Schleimann F. Seven Case Studies. In: Peters D, El-Saharty S, Siadat B, Janovsky K, Vujicic M, editors. Improving Health Service Delivery in Developing Countries: From Evidence to Action. Washington, DC: The World Bank; 2009.

46 Grant JP. Reaching the unreached: a miracle in the making. Asia Pac J Public Health. 1991;5:154-62. Medline:1818613 doi:10.1177/101053959100500209

47 Mahler H. Address to the 61st World Health Assembly. 2008. Available: http://www.who.int/mediacentre/events/2008/wha61/hafdan_mahler_speech/en/. Accessed: 26 February 2017.

48 United Nations. Sustainable Development Goals. 2015. Available: https://sustainabledevelopment.un.org/topics/sustainabledevelopmentgoals. Accessed: 26 February 2017.

49 Prata N, Vahidnia F, Potts M, Dries-Daffner I. Revisiting community-based distribution programs: are they still needed? Contraception. 2005;72:402-7. Medline:16307960 doi:10.1016/j.contraception.2005.06.059

50 Farmer P, Leandre F, Mukherjee JS, Claude M, Nevil P, Smith-Fawzi MC, et al. Community-based approaches to HIV treatment in resource-poor settings. Lancet. 2001;358:404-9. Medline:11502340 doi:10.1016/S0140-6736(01)05550-7

51 Chowdhury AM, Chowdhury S, Islam MN, Islam A, Vaughan JP. Control of tuberculosis by community health workers in Bangladesh. Lancet. 1997;350:169-72. Medline:9250184 doi:10.1016/S0140-6736(96)11311-8

52 Kidane G, Morrow RH. Teaching mothers to provide home treatment of malaria in Tigray, Ethiopia: a randomised trial. Lancet. 2000;356:550-5. Medline:10950232 doi:10.1016/S0140-6736(00)02580-0

53 Neupane D, Kallestrup P, McLachlan CS, Perry H. Community health workers for non-communicable diseases. Lancet Glob Health. 2014;2:e567. Medline:25304630 doi:10.1016/S2214-109X(14)70303-1

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PAPERS

Prioritizing medication safety in care of people with cancer: clinicians' views on main problems and solutions

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Background Cancer care is liable to medication errors due to the complex nature of cancer treatment, the common presence of comorbidities and the involvement of a number of clinicians in cancer care. While the frequency of medication errors in cancer care has been reported, little is known about their causal factors and effective prevention strategies. With a unique insight into the main safety issues in cancer treatment, frontline staff can help close this gap. In this study, we aimed to identify medication safety priorities in cancer patient care according to clinicians in North West London using PRIORITIZE, a novel priority–setting approach.

Methods The project steering group determined the scope, the context and the criteria for prioritization. We then invited North West London cancer care clinicians to identify and prioritize main causes for, and solutions to, medication errors in cancer care. Forty cancer care providers submitted their suggestions which were thematically synthesized into a composite list of 20 distinct problems and 22 solutions. A group of 26 clinicians from the initial cohort ranked the composite list of suggestions using predetermined criteria.

Results The top ranked problems focused on patients' poor understanding of treatments due to language or education difficulties, clinicians' insufficient attention to patients' psychological distress, and inadequate information sharing among health care providers. The top ranked solutions were provision of guidance to patients and their carers on what to do when unwell, pre–chemotherapy work–up for all patients and better staff training. Overall, clinicians considered improved communication between health care providers, quality assurance procedures (during prescription and monitoring stages) and patient education as key strategies for improving cancer medication safety. Prescribing stage was identified as the most vulnerable to medication safety threats. The highest ranked suggestions received the strongest agreement among the clinicians.

Conclusions Clinician–identified priorities for reducing medication errors in cancer care addressed various aspects of cancer treatment. Our findings open up an opportunity to assess the congruence between health care professional suggestions, currently implemented patient safety policies and evidence base.

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Medication errors, defined as preventable events that may lead to inappropriate medication use or patient harm, are a serious and common threat to cancer patients [1,2]. In an oncology outpatient department in the US, medication errors occurred in 7% of adults and 19% of children [3]. A system-

atic review reported that approximately 20% of palliative cancer patients were prescribed potentially inappropriate medications [4]. Cancer treatment is highly predisposed to errors due to its multifaceted and dynamic nature. Chemotherapy, consisting of complex regimens of potent and potentially toxic drugs, has to be administered repeatedly, according to protocols and frequently adapted to patients' conditions. This is coupled with a considerable burden of concurrent illnesses, a common need for supportive therapy and the involvement of many different clinicians in provision of care [5–7].

The evidence on cancer medication safety, ie, freedom from preventable harm with medication use, mostly focuses on rates and types of medication errors in specific forms of chemotherapy or cancers [8]. It includes analysis of patient medical records, incident reports and prospective observational studies [9–11]. Little is known about the main causal factors to cancer medication errors and the specific interventions that could lead to significant improvements in safety.

One way of addressing this lack of evidence is by exploring clinicians' unique insight into the safety and quality of cancer treatment [12]. Cancer care clinicians offer an important source to guide our understanding of the cancer safety issues which has not to date been routinely and formally drawn on. In this study, we aimed to identify priorities for medication safety in care of people with cancer according to cancer care clinicians in North West London.

METHODS

PRIORITIZE and the study scope

We developed and implemented PRIORITIZE, an adaptation of Child Health and Nutrition Research Initiative (CHNRI) approach, to determine the main problems and solutions relating to medication safety in cancer care (**Figure 1**). The CHNRI methodology has been used extensively to inform policymakers, funding bodies and international organizations about priorities for research [13–15]. PRIORITIZE focuses on priorities in health care services delivery using clinicians' as experts and determines priorities using two corresponding viewpoints: problems and solutions. The final output of this approach is presentation of the top priorities categorized according to level for the implementation: a) actions for clinicians b) actions for health care organisations and hospitals and c) actions for health system custodians. As this study was deemed a service evaluation and an innovative quality and safety improvement initiative, it did not require ethics or governance approval [16,17]. During the study's first stage, the project steering group (Imperial College Health Partners), decided to focus on two topics relating to cancer care patient safety: medication safety and delayed diagnosis (presented elsewhere) [18]. Imperial College Health Partners is an organization that unifies NHS health care providers, clinical commissioning groups and leading universities across North West London with the aim of improving quality of health care delivery [19]. The steering group also chose the criteria to guide prioritisation of collated suggestions, ie, scoring of problems and solutions (**Box 1**).

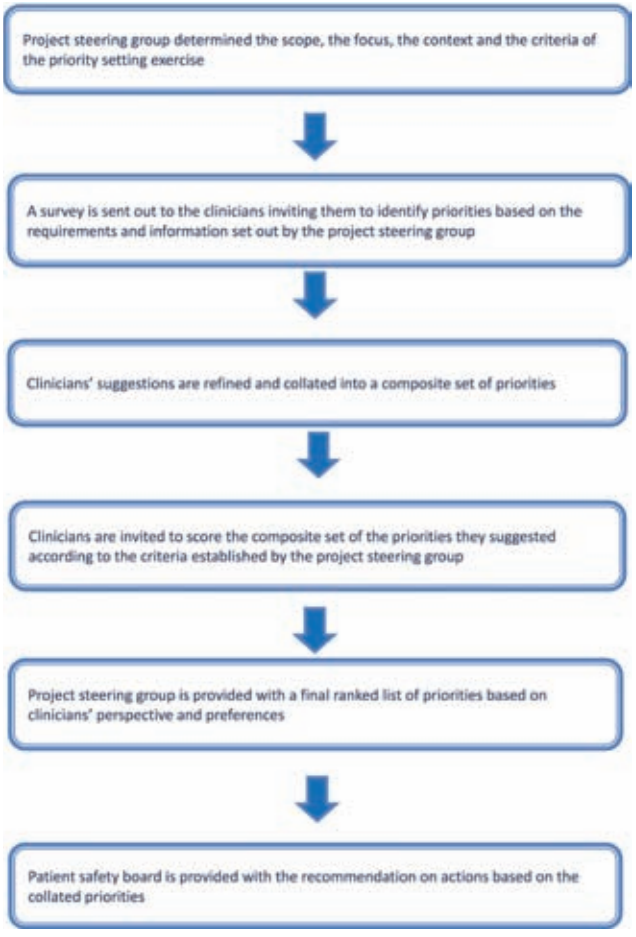


Figure 1. PRIORITIZE methodology flow diagram.

Identifying cancer medication safety priorities

We developed an open–ended questionnaire for clinicians to identify the main problems and solutions relating to medication safety in cancer care. It was piloted on a smaller sample of four primary care physicians and trainees recruited through our Department and amended based on the received feedback (see Appendix S1 in **Online Supplemen-**

Box 1. Scoring criteria for prioritization of collated suggestions

For problems:
- Frequency – This patient safety threat is common.
- Severity – This patient safety threat leads to high rates of mortality, morbidity and incapacity.
- Inequity – This patient safety threat affects lower socio–economic groups or ethnic minorities more than other groups.
- Economic impact – The consequences of this patient safety threat are costly to the healthcare system.
- Responsiveness to solution – This incident is amenable to a solution within 5 years.

For solutions:
- Feasibility – The implementation of this solution is feasible.
- Cost–effectiveness – This solution is cost–effective.
- Potential for saving lives – This solution would save lives.

tary Document). The questionnaire was distributed in a paper–based and an equivalent online version and disseminated via email lists and snowballing (participants were asked to forward the survey to colleagues). We targeted oncology consultants, general practitioners, trainees, nurses and pharmacists.

Scoring of cancer medication safety priorities

The collected suggestions were examined using content analysis with open coding to categorise the free–text responses. Suggestions which were sufficiently similar were combined. In the second phase, we asked clinicians to categorize the suggestions using the predetermined scoring criteria and four options: 1 for "Yes – I agree with the statement", 0 for "No – I do not agree with the statement", 0.5 for "Unsure – I am unsure whether or not I agree" and blank (no response) for "Unaware – I do not feel sufficiently familiar or confident to score this suggestion" (see Appendix S2 in **Online Supplementary Document**). As the scoring was time demanding (an average 1 hour to complete), we offered a token payment to the participants in a form of a £50 voucher. Clinicians who performed scoring of the priorities were arbitrarily selected from the initial cohort of cancer care clinicians.

Computation of priority scores and average expert agreement

The data from the scoring sheet was collected and analyzed with SPSS (v. 21), IBM, New York, USA. We calculated the intermediate scores (ie, scores for each criterion for every suggestion) by adding up all the answers ("1," "0" or "0.5") and dividing the sum by the number of received answers. Intermediate scores for suggestions were therefore assigned a value between 0 to 100. The overall priority score for every suggestion was then computed as the mean of the scores for each criterion (ie, five criteria for problems and three for solutions). Suggestions that were ranked higher received more "Yes" responses for each of the criteria and a higher overall score. Kappa statistics was deemed an inappropriate test to determine inter–rater agreement in this study due to the sample size, the non–standardised categorical nature of data, the option of blank response to some statements and the number of our different criteria used for scoring. Instead, we evaluated inter–rater agreement using the average expert agreement (AEA) (**Figure 2**) [13]. AEA is the share of scorers selecting the most common score for each research question and indicates the degree of clinicians' agreement on priorities. AEA was calculated using the formula in **Figure 2**.

We classified the collated suggestions for medication safety in cancer care using an adapted model of medication delivery and the London Protocol, a framework for aa comprehensive investigation and analysis of patient safety incident, for use by clinicians, risk and patient safety managers, researchers and others wishing to reflect and learn from clinical incidents [20,21] (see Appendix S3 in **Online Supplementary Document**).

$$AEA = \frac{1}{5} \times \sum_{q=1}^{5} \frac{N\ (scorers\ \ who\ \ provided\ \ the\ \ most\ \ frequent\ \ response)}{N\ (scorers)}$$

$$AEA = \frac{1}{3} \times \sum_{q=1}^{3} \frac{N\ (scorers\ \ who\ \ provided\ \ the\ \ most\ \ frequent\ \ response)}{N\ (scorers)}$$

Figure 2. Formula for calculating average expert agreement; q is a question that experts are being asked to evaluate competing patient safety threats.

RESULTS

In the first phase we invited around 780 cancer care clinicians and received 40 complet-

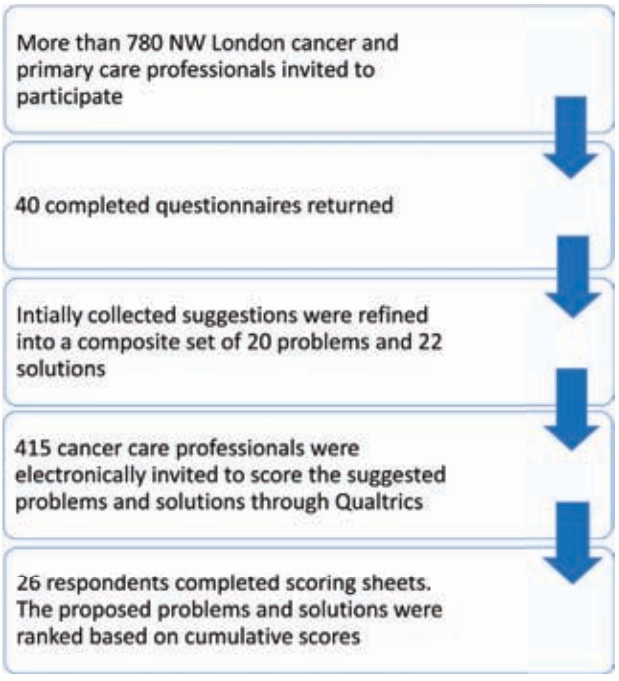


Figure 3. Participants' flow diagram.

ed questionnaires with the majority by oncology consultants (n = 15, 37.5%) and specialty trainees (n = 15, 37.5%) (see Appendix S4 in **Online Supplementary Document**). We collated 101 problems and 53 solutions relating to cancer medication safety and thematically merged them into 20 distinct problems and 22 solutions. From the phase 1 cohort, 415 cancer care clinicians were invited to score the composite list of suggestions resulting in 26 fully completed scoring sheets (**Figure 3**).

The top ranked problems leading to medication errors in cancer treatment according to clinicians are patients' poor understanding of treatments due to language or education difficulties, insufficient attention to psychological distress or illness and clinicians' lack of access to information on treatments administered in other hospitals or by other health care providers (**Table 1**). The top three solutions to medication safety threats are guidance to patients and their carers on what to do when unwell, an appropriate pre–chemotherapy work up for all patients and better training of staff. Clinicians identified prescribing stage as the most vulnerable to medication safety threats (**Table 2**).

Overall, the proposed problems focused on poor communication among clinicians and with patients; inadequate quality assurance processes; errors during the prescription and monitoring stage and patients' lack of awareness or poor understanding of chemotherapy (Table S5 in **Online Supplementary Document**). Proposed solutions overall focused on improving information integration and communication among health care services, introducing quality assurance interventions during the prescribing and monitoring stage, and enhanced patient empowerment and education (Table S6 in **Online Supplementary Document**).

Table 1. Top ten medication–related problems in cancer care*

Rank	Proposed medication–related problems in cancer care	Total Priority Score	Breakdown point in the medication process	Contributor factor
1	Patients with poor understanding of treatments due to language or education difficulties may miss treatments or not understand the importance of reporting side effects leading to worsening of illness	75.5	Administering/ monitoring	Patient
2	Insufficient attention to recognizing and managing serious psychological distress or illness due to oncological problem and treatment leads to non–compliance and/or worsening of patient's condition	66	Monitoring	Individual staff
3	Inability to obtain information on treatments given in other hospitals or by other health care providers eg, palliative care team mean that the oncology team may administer inappropriate treatments or delay treatment while waiting for the information	62.5	Administering	Task design
4	Complications of central access lines inserted for chemotherapy lead to patient morbidity or delayed treatments	59.5	Administering	–
5	Patients have difficulty accessing acute oncology services outside of routine hours leading to delayed treatment of side effects or complications with significant negative consequences (eg, preventable hospitalizations)	58	Monitoring	Organisation
6	Toxicity or severe allergic reactions from chemotherapy	55.5	Administering	–
7	Drugs may be stopped for procedures eg, anticoagulants but not restarted leading to adverse events for patients such as thromboembolic events	55	Administering	Individual staff
8	Interactions between medications are not automatically highlighted meaning that inappropriate drugs may be administered together	53.5	Administering	Task design
9	Patients do not inform their oncologist of side effects meaning that the chemotherapy dose is not altered and the side effects become worse	52	Monitoring	Patient
10	Too little information on chemotherapy for patients prior to starting treatment meaning that they do not know or recognize signs of complications or serious illness and who and when to contact	50.5	Prescribing	Patient

*(Clinicians scored problems using the following criteria: frequency, severity, inequity, economic impact and responsiveness to solution (**Box 1**). The scoring options were 1 for "yes (eg, this problem is common)", 0 for "no (eg, this problem is uncommon)", 0.5 for "unsure (eg, I am unsure if this problem is common)" and blank for "unaware (eg, I do not know if his problem is common)". Total Priority score is the mean of scores for each of the five criteria and is ranging from 0 to 100. Higher ranked problems received more "Yes" responses for each of the criteria and a higher score). All tables use clinicians' verbatim statements which were only exceptionally reworded for clarity.

Table 2. Top ten solutions to medication-related problems in cancer care*

Rank	Proposed solution for medication–related problems in cancer care	Total Priority Score	Breakdown point in the medication process	Related defense barrier
1	Provide information for patients and their carers on what to do when unwell eg, card with contact numbers	93.3	Monitoring	Patient
2	All patients should receive an appropriate pre–chemotherapy work up	92.5	Administering	Task design
3	Improve training of staff	91.7	Prescribing, transcribing, dispensing, administering, monitoring	Working environment
4	Develop a checklist for clinicians so that important points in the history or tests are not missed	90.0	Prescribing	Task design
5	Ensure patients have relevant written information for community clinicians to ensure that appropriate treatments are given	89.2	Administering	Patient
6	Enable staff to access patient records remotely so that on call staff are fully aware of the patient's history	87.5	Prescribing, monitoring	Task design
7	Improve the staff:patient ratios	86.7	Prescribing, transcribing, dispensing, administering, monitoring	Working environment
8	Advise patients to check their temperature regularly to detect sepsis earlier	85.8	Monitoring	Patient
9	Improve communication with pharmacy about drugs and dose adjustments so that delays in drug administration do not occur	85.8	Transcribing	Team
10	Attach the chemotherapy prescription chart to the routine drug chart so drugs are not missed	84.2	Prescribing	Task design
11	Advise patients to contact hospital early in day if unwell to ensure appropriate staff available	84.2	Monitoring	Patient

*(Clinicians scored solutions using feasibility and cost–effectiveness solutions (**Box 1**). The scoring options were 1 for "yes (eg, this solution is feasible)", 0 for "no (eg, this solution is unfeasible)", 0.5 for "unsure (eg, I am unsure if this solution is feasible)" and blank for "unaware (eg, I do not know if this solution is feasible)". Total Priority score is the mean of the scores for each of the two criteria and is ranging from 0 to 100. Higher ranked solutions).

Several of the proposed problems focused on patients' role in cancer medication safety (Table S5 in **Online Supplementary Document**). They included poor understanding of treatments due to language or education difficulties, not informing their oncologist about the side effects, not recognizing complications and not knowing whom to inform, and attending their GP rather than oncology services (Table S5 in **Online Supplementary Document**). Correspondingly, patient empowerment and education were highlighted as key safety priorities (Table S6 in **Online Supplementary Document**). Pertinent suggestions included tailored guidance on what to do when feeling unwell, having treatment records to ensure administration of appropriate treatment from the community providers, increasing the number of clinical nurse specialists to provide patient education and continuity of care as well as encouraging frequent body temperature checks and increased physical activity.

Clinicians viewed patients from lower socio–economic group as more commonly affected by poor understanding of treatment, clinicians' inattention to comorbidities and lack of access to information on their treatment from other health care providers. This group of patients was also considered more likely to receive less information on chemotherapy as well as to visit their GP rather than oncology service for complications from chemotherapy leading to delays in treatment or inappropriate advice or treatments (Table S5 in **Online Supplementary Document**).

Suggestions that were seen as least important for cancer medication safety overall related to issues with the chemotherapy prescribing system, the need for more frequent blood tests, chemotherapy dose calculation errors and the use of personalised medicine approaches. The top ranked suggestions had the highest AEA, ie, there was a stronger consensus among clinicians for the top suggestions compared to those ranked lower. Proposed solutions received higher AEA scores compared to problems, ie, clinicians agreed more on the ranking of solutions compared to the ranking of problems (Table S5 in **Online Supplementary Document**).

DISCUSSION

In this study, clinicians from North West London identified priorities for improving cancer medication safety. The top ranked problems were patients' poor understanding of treatments, clinicians' insufficient attention to patients' psychological distress and poor information exchange among health care providers.

The top ranked solutions were guidance to patients and their carers on what to do when unwell, an appropriate pre–chemotherapy work up for all patients and better staff training. Overall, clinicians considered better communication between health care providers, quality assurance procedures and patient education as key to ensuring cancer medication safety. The highest ranked suggestions received the strongest agreement among the clinicians. Many identified suggestions for cancer medication safety are feasible, affordable and could contribute to improvements to medication safety in cancer care.

We have also used PRIORITZE to identify primary care clinicians' medication safety priorities in primary care [22]. While the overarching themes were the same (eg, patient education, communication and information sharing across different health care providers and quality assurance procedures), particular priorities differ significantly. Primary care medication safety priorities were broader in scope and included several suggestions relating to transfer of care between different health care providers. Conversely, cancer medication priorities seem more focused and many addressed the need for improved sharing of information and communication with patients.

According to the clinicians in our study, cancer patients lack information about the potential side–effects and who to turn to in case of treatment complications. This was seen as more common in patients from lower socio–economic groups or ethnic minorities. Such lack of guidance is concerning given the essential role patients can have as 'vigilant partners' in prevention of chemotherapy medication errors [20,21]. In educating patients about their cancer treatment, health care professionals should consider the content, structure, delivery mode, potential information overload and a need for message reinforcement [9]. Corresponding solutions in our study included provision of tailored information on what to do and who to call if feeling poorly, instructing patients to check their temperature regularly and to contact hospital early in the day if unwell, encouraging patients to undertake increased physical activity and increasing the number of clinical nurse specialists to improve patient education.

The collated suggestions, while more detailed, correspond in part to the author–nominated list of preventive interventions for medication errors in a US oncology outpatient department [1]. Improved communication, standardized ordering sheet and patient education about home medications have been highlighted in both studies as major safety threats. Furthermore, fragmentation in cancer treatment noted in this study has also been observed in other settings [7,23–25]. A recently published randomized controlled trial on pharmacist–led medication reconciliation intervention, aligned with some of the clinician–identified solutions in our study (eg, enabling remote access to patient records and closer links with pharmacy), showed reduction in the incidence of errors in cancer patient [26]. However, the effectiveness of other collated solutions is unclear as the evidence on effective interventions to reduce medication errors in cancer care is lacking [27].

Limitations

We recruited a small, self–selected sample, potentially different from the clinicians refusing to take part in this study which may have influenced the generalizability of our findings. The low response rate is common in physician surveys, especially those focusing on emotionally–laden topics and including open–ended questions [28,29]. Furthermore, the number of participants corresponds to those in other priority–setting exercises involving health care professionals or employing the CHNRI methodology [30–32]. While our findings correspond to the existing literature, it is unclear how applicable they are to other settings. Patient safety incidents are often context–specific as reflected in a study on medication errors across different outpatient oncology clinics [3]. The advantage of PRIORITIZE is that allows discovery of local safety priorities and customization of patient safety interventions to the study setting.

In comparison to a standard Delphi approach, in PRIORITIZE the number of discussed suggestions is larger, the contribution of all participants equivalent and the prioritization transparent. Yet, as a novel priority–setting methodology, PRIORITIZE could be further refined and validated. The scoring of the solutions could be streamlined through the development of a platform–agnostic information technology tool. Some problems identified in our study related to chemotherapy–related adverse effects (eg, "toxicity or severe allergic reactions from chemotherapy") rather than causal factors for safety issues. However, by inviting clinicians to identified both problems and solutions, we managed to capture relevant data. In future, this could be enhanced by providing examples which would guide the specificity of responses. Recent CHNRI–focused validity assessments reveal that, in most cases and under most assumption, the collective knowledge will be more accurate than the knowledge of an "average" individual [32]. It also shows that that the collective opinion of around 50 experts expressed was sufficient to reach steady find-

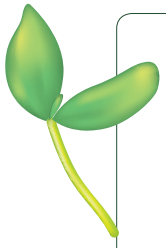
ings and consensus on rankings [33]. These promising insights could also be verified as part of the PRIORITIZE approach.

Implications for practice and policy

Using a bottom–up approach with clinicians as change agents, we collated a number of concrete, locally relevant and affordable suggestions on cancer medication safety priorities. The suggestions focused on information integration among cancer care providers, implementation of quality assurance procedures and stronger patient education. Some suggestions correlated (eg, "Inability to obtain information on treatments given in other hospitals or by other healthcare providers" and "Enable staff to access patient records remotely"), reinforcing the importance of certain priorities.

Clinicians often report feeling marginalised in patient safety policy development as well as hesitant toward incident reporting due to lack of anonymity, time and the risk of victimisation [34–36]. The information produced by the incident reporting system has been found to be inaccurate, incomplete and difficult to analyze, making it hard to spot dangerous trends or problem [37,38]. Patient safety analytical approaches such as root cause analysis are unable to detect latent causes of error if health care professionals are uncomfortable with exposing safety weaknesses [39]. PRIORITIZE enables anonymous and structured voicing of safety concerns from a large number of health care providers [40–42]. It corresponds to calls for greater inclusion of health care staff in patient safety research, uncovering of local patient safety priorities and development of solutions to safety issues [43].

Future steps should include comparison of local cancer safety policies, organisational data on cancer medication safety and collated clinician–identified priorities to signpost the type of intervention or research that is needed. There is also a need for robust, experimental studies to help determine effective cancer medication safety strategies and support inclusion of clinician–identified suggestions into safety polices. Finally, PRIORITIZE could be used as a routine patient safety assessment tool to trigger staff's involvement, evaluate patient safety culture, enable country–wide patient safety comparison and development of locally tailored safety strategies.



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REFERENCES

1 Walsh KE, Dodd KS, Seetharaman K, Roblin DW, Herrinton LJ, Von Worley A, et al. Medication errors among adults and children with cancer in the outpatient setting. J Clin Oncol. 2009;27:891-6. Medline:19114695 doi:10.1200/JCO.2008.18.6072

2 National Coordinating Council for Medication Error Reporting and Prevention. About Medication Errors. 2017. Available: http://www.nccmerp.org/about-medication-errors. Accessed: 1 May 2017.

3 Walsh KE, Dodd KS, Seetharaman K, Roblin DW, Herrinton LJ, Von Worley A, et al. Medication errors among adults and children with cancer in the outpatient setting. J Clin Oncol. 2009;27:891-6. Medline:19114695 doi:10.1200/JCO.2008.18.6072

4 Lindsay J, Dooley M, Martin J, Fay M, Kearney A, Barras M. Reducing potentially inappropriate medications in palliative cancer patients: evidence to support deprescribing approaches. Support Care Cancer. 2014;22:1113-9. Medline:24362845 doi:10.1007/s00520-013-2098-7

5 Norton PG, Baker GR. Patient safety in cancer care: a time for action. J Natl Cancer Inst. 2007;99:579-80. Medline:17440151 doi:10.1093/jnci/djk161

6 Ko C, Chaudhry S. The need for a multidisciplinary approach to cancer care. J Surg Res. 2002;105:53-7. Medline:12069502 doi:10.1006/jsre.2002.6449

7 Riechelmann RP, Tannock IF, Wang L, Saad ED, Taback NA, Krzyzanowska MK. Potential drug interactions and duplicate prescriptions among cancer patients. J Natl Cancer Inst. 2007;99:592-600. Medline:17440160 doi:10.1093/jnci/djk130

8 Institute for Safe Medication Practices Canada. ISMP Canada: definition of terms. 2007. Available: https://www.ismp-canada.org/definitions.htm. Accessed: 1 May 2017.

9 Schwappach DLB, Wernli M. Medication errors in chemotherapy: incidence, types and involvement of patients in prevention. A review of the literature. Eur J Cancer Care (Engl). 2010;19:285-92. Medline:19708929 doi:10.1111/j.1365-2354.2009.01127.x

10 Markert A, Thierry V, Kleber M, Behrens M, Engelhardt M. Chemotherapy safety and severe adverse events in cancer patients: strategies to efficiently avoid chemotherapy errors in in- and outpatient treatment. Int J Cancer. 2009;124:722-8. Medline:18989899 doi:10.1002/ijc.23991

11 Leung M, Bland R, Baldassarre F, Green E, Kaizer L, Hertz S, et al. Safe administration of systemic cancer therapy Part 1: safety during chemotherapy ordering, transcribing, dispensing, and patient identification. 2012. Available: ttps://www.cancercare.on.ca/common/pages/UserFile.aspx?fileId=154923. Accessed: 1 May 2017.

12 Ulas A, Silay K, Akinci S, Dede DS, Akinci MB, Sendur MAN, et al. Medication errors in chemotherapy preparation and administration: a survey conducted among oncology nurses in Turkey. Asian Pac J Cancer Prev. 2015;16:1699-705. Medline:25773812 doi:10.7314/APJCP.2015.16.5.1699

13 Rudan I, Chopra M, Kapiriri L, Gibson J, Ann Lansang M, Carneiro I, et al. Setting priorities in global child health research investments: universal challenges and conceptual framework. Croat Med J. 2008;49:307-17. Medline:18581609 doi:10.3325/cmj.2008.3.307

14 Rudan I, Gibson JL, Ameratunga S, El Arifeen S, Bhutta ZA, Black M, et al. Setting priorities in global child health research investments: guidelines for implementation of CHNRI method. Croat Med J. 2008;49:720-33. Medline:19090596 doi:10.3325/cmj.2008.49.720

15 Rudan I, El Arifeen S, Bhutta ZA, Black RE, Brooks A, Chan KY, et al. Setting research priorities to reduce global mortality from childhood pneumonia by 2015. PLoS Med. 2011;8:e1001099. Medline:21980266 doi:10.1371/journal.pmed.1001099

16 NHS Health Research Authority. Defining Research.2013. Available: http://www.hra.nhs.uk/documents/2016/06/defining-research.pdf. Accessed: 1 May 2017.

17 Guidance IRAS. Integrated Research Application System Project Filter Collated Guidance. 2009. Available: www.myresearchproject.org.uk/help/Help Documents/IRAS_v_2_3_-_Revised_collated_Project_Filter_QSG_%252829_June_09%2529.doc. Accessed: 1 May 2017.

18 Car LT, Papachristou N, Urch C, Majeed A, El–Khatib M, Aylin P, et al. Preventing delayed diagnosis of cancer: clinicians' views on main problems and solutions. J Glob Health. 2016;6:020901. Medline:28028437 doi:10.7189/jogh.06.020901

19 Imperial College Health Partners. Who we are. 2016. Available: http://imperialcollegehealthpartners.com/who-we-are/. Accessed: 1 May 2017.

20 Preventing Medication Errors. Quality Chasm Series. The National Academies Press; Washington, DC: 2007.

21 Clinical Safety Research Unit ICL. Systems analysis of clinical incidents: London protocol. 2001. Available: https://www1.imperial.ac.uk/resources/C85B6574-7E28-4BE6-BE61-E94C3F6243CE/londonprotocol_e.pdf. Accessed: 1 May 2017.

22 Tudor Car L, Papachristou N, Gallagher J, Samra R, Wazny K, El-Khatib M, et al. Identification of priorities for improvement of medication safety in primary care: a PRIORITIZE study. BMC Fam Pract. 2016;17:160. Medline:27852240 doi:10.1186/s12875-016-0552-6

23 Tamblyn RM, McLeod PJ, Abrahamowicz M, Laprise R. Do too many cooks spoil the broth? Multiple physician involvement in medical management of elderly patients and potentially inappropriate drug combinations. CMAJ. 1996;154:1177-84. Medline:8612253

24 Hannisdal E, Arianson H, Braut GS, Schlichting E, Vinnem JE. A risk analysis of cancer care in Norway: the top 16 patient safety hazards. Jt Comm J Qual Patient Saf. 2013;39:511-6. Medline:24294679 doi:10.1016/S1553-7250(13)39067-9

25 Lipczak H, Knudsen JL, Nissen A. Safety hazards in cancer care: findings using three different methods. BMJ Qual Saf. 2011;20:1052-6. Medline:21712371 doi:10.1136/bmjqs.2010.050856

26 Vega TG-C, Sierra-Sánchez JF, Martínez-Bautista MJ, García-Martín F, Suárez-Carrascosa F, Baena-Cañada JM. Medication reconciliation in oncological patients: a randomized clinical trial. J Manag Care Spec Pharm. 2016;22:734-40. Medline:27231800 doi:10.18553/jmcp.2016.15248

27 Vincent C, Amalberti R. Safer Healthcare. 2016. Available: http://link.springer.com/10.1007/978-3-319-25559-0. Accessed: 9 March 2016.

28 Wiebe ER, Kaczorowski J, MacKay J. Why are response rates in clinician surveys declining? Can Fam Physician. 2012;58:e225-8. Medline:22611609

29 VanGeest JB, Johnson TP, Welch VL. Methodologies for improving response rates in surveys of physicians: a systematic review. Eval Health Prof. 2007;30:303-21. Medline:17986667 doi:10.1177/0163278707307899

30 Nair H, Verma VR, Theodoratou E, Zgaga L, Huda T, Simões EAF, et al. An evaluation of the emerging interventions against Respiratory Syncytial Virus (RSV)-associated acute lower respiratory infections in children. BMC Public Health. 2011;11 Suppl 3:S30. Medline:21501449 doi:10.1186/1471-2458-11-S3-S30

31 Wiseman V. Comparing the preferences of health professionals and members of the public for setting health care priorities: experiences from Australia. Appl Health Econ Health Policy. 2005;4:129-37. Medline:16162032 doi:10.2165/00148365-200504020-00007

32 Bahl R, Martines J, Ali N, Bhan MK, Carlo W, Chan KY, et al. Research priorities to reduce global mortality from newborn infections by 2015. Pediatr Infect Dis J. 2009;28:S43-8. Medline:19106763 doi:10.1097/INF.0b013e31819588d7

33 Yoshida S, Rudan I, Cousens S. Setting health research priorities using the CHNRI method: VI. quantitative properties of human collective opinion. J Glob Health. 2016;6:010503. Medline:27350874 doi:10.7189/jogh.06.010503

34 Bishop AC, Macdonald M. Patient involvement in patient safety: a qualitative study of nursing staff and patient perceptions. J Patient Saf. 2014. Medline:25010194 doi:10.1097/PTS.0000000000000123

35 Singh H, Thomas E. Identifying diagnostic errors in primary care using an electronic screening algorithm. Arch Intern Med. 2007;167:302-8. Medline:17296888 doi:10.1001/archinte.167.3.302

36 Francis R. Freedom to speak up - A review of whistleblowing in the NHS. NHS Improvement; London: 2015.

37 The NIHR Imperial Patient Safety Translational Research Centre. Patient Safety 2030. 2016. Available: http://www.imperial.ac.uk/media/imperial-college/institute-of-global-health-innovation/centre-for-health-policy/Patient-Safety-2030-Report-VFinal.pdf. Accessed: 1 May 2017.

38 Weaver SJ, Dy S, Lubomski LH, Wilson R. Promoting a Culture of Safety. Agency for Healthcare Research and Quality (US). Available: http://www.ncbi.nlm.nih.gov/books/NBK133394/. Accessed: 7 September 2016.

39 Nieva VF. Safety culture assessment: a tool for improving patient safety in healthcare organizations. Qual Saf Health Care. 2003;12 Suppl 2:ii17-23. Medline:14645891 doi:10.1136/qhc.12.suppl_2.ii17

40 Hindin MJ, Christiansen S, Ferguson BJ. Setting research priorities for adolescent sexual and reproductive health in low- and middle-income countries. Bull World Health Organ. 2013;91:10-8. Medline:23397346 doi:10.2471/BLT.12.107565

41 Dean S, Rudan I, Althabe F, Webb Girard A, Howson C, Langer A, et al. Setting research priorities for preconception care in low- and middle-income countries: aiming to reduce maternal and child mortality and morbidity. PLoS Med. 2013;10:e1001508. Medline:24019762 doi:10.1371/journal.pmed.1001508

42 Lawn JE, Bahl R, Bergstrom S, Bhutta ZA, Darmstadt GL, Ellis M, et al. Setting research priorities to reduce almost one million deaths from birth asphyxia by 2015. PLoS Med. 2011;8:e1000389. Medline:21305038 doi:10.1371/journal.pmed.1000389

43 Improving Quality NHS. Health Secretary launches new patient safety collaboratives. 2014. Available: http://www.nhsiq.nhs.uk/news-events/news/health-secretary-launches-new-patient-safety-collaboratives.aspx. Accessed: 30 June 2015.

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PAPERS

Prioritizing research for integrated implementation of early childhood development and maternal, newborn, child and adolescent health and nutrition platforms

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Background Existing health and nutrition services present potential platforms for scaling up delivery of early childhood development (ECD) interventions within sensitive windows across the life course, especially in the first 1000 days from conception to age 2 years. However, there is insufficient knowledge on how to optimize implementation for such strategies in an integrated manner. In light of this knowledge gap, we aimed to systematically identify a set of integrated implementation research priorities for health, nutrition and early child development within the 2015 to 2030 timeframe of the Sustainable Development Goals (SDGs).

Methods We applied the Child Health and Nutrition Research Initiative method, and consulted a diverse group of global health experts to develop and score 57 research questions against five criteria: answerability, effectiveness, deliverability, impact, and effect on equity. These questions were ranked using a research priority score, and the average expert agreement score was calculated for each question.

Findings The research priority scores ranged from 61.01 to 93.52, with a median of 82.87. The average expert agreement scores ranged from 0.50 to 0.90, with a median of 0.75. The top–ranked research question were: i) "How can interventions and packages to reduce neonatal mortality be expanded to include ECD and stimulation interventions?"; ii) "How does the integration of ECD and MNCAH&N interventions affect human resource requirements and capacity development in resource–poor settings?"; and iii) "How can integrated interventions be tailored to vulnerable refugee and migrant populations to protect against poor ECD and MNCAH&N outcomes?". Most highly–ranked research priorities varied across the life course and highlighted key aspects of scaling up coverage of integrated interventions in resource–limited settings, including: workforce and capacity development, cost–effectiveness and strategies to reduce financial barriers, and quality assessment of programs.

Conclusions Investing in ECD is critical to achieving several of the SDGs, including SDG 2 on ending all forms of malnutrition, SDG 3 on ensuring health and well–being for all, and SDG 4 on ensuring inclusive and equitable quality education and promotion of life–long learning opportunities for all. The generated research agenda is expected to drive action and investment on priority approaches to integrating ECD interventions within existing health and nutrition services.

The Millennium Development Goals (MDGs), especially MDGs 4 and 5, ushered in unprecedented attention to maternal and child health globally, with a specific focus on survival. As 2015 drew to a close, the world witnessed almost a halving of maternal and child deaths globally and recommitted to accelerating progress via the Sustainable Development Goals (SDGs) [1,2]. However, unlike the MDGs, the SDG targets go beyond survival, recognizing that reduction in child mortality without explicit attention to early child development (ECD) does not necessarily translate into long–term health benefits and well-being over the life course. ECD encompasses the period of early life, considered by many to include the period from conception to age 8 years, that is critical for development of foundational sensory–motor, cognitive, language, and socio–emotional competencies [3]. A recent estimate based on prevalence of stunting and extreme poverty indicates that 250 million children in low– and middle–income countries (LMICs) are at risk of failing to reach their developmental potential [4]. One third of preschool–aged children living in LMICs are not meeting basic milestones in either their cognitive or socio–emotional development, with an additional 16.7% experiencing stunting [5]. Developmental deficits are likely to negatively affect academic performance and limit opportunities in adulthood, thereby perpetuating an intergenerational cycle of poverty [4]. Risks to development from poverty and stunting are estimated to result in about a 25% annual reduction in income–earning potential in adulthood [6]. Investing in ECD is therefore a matter of social justice as well as economic urgency, and must be politically prioritized; it presents an opportunity to disrupt this insidious cycle of poverty and exclusion and allow all children and communities to fully realize their human potential.

Although there is a range of options available for promoting ECD during the pre–school and school–age periods, there is increasing interest in potential platforms and opportunities to deliver such interventions in the first 1000 days from conception to age 2 years. Existing health and nutrition services for mothers and infants present readily accessible potential platforms for scaling up delivery of ECD interventions [6]. Integration and implementation of ECD programs into the health and nutrition sectors aims to achieve

higher coverage as well as sustainable, and potentially equitable reach of ECD interventions [6]. As outlined in **Figure 1**, this integrated implementation can be accomplished by leveraging existing delivery platforms to reach at–risk children and their caregivers within sensitive windows across the life course. **Figure 1** is adapted from Vaivada et al [7] and Black et al [8].

Despite the focus in recent years on maternal, newborn, child and adolescent health and nutrition (MNCAH&N) interventions and programs in either resource–limited settings or low– and middle–income countries (LMICs), there is limited knowledge on how best to integrate and implement ECD programs therein. The paucity of integrated programs in LMICs [9] and lack of rigorous evaluations of these existing programs, underscore the need for appropriate research to accelerate progress [10]. We undertook an expert consensus process using standardized methods to identify the top research priorities on the integrated implementation of ECD and MNCAH&N interventions in LMICs, with the aim of informing global research investments over the next fifteen years, ie, the timeline of the SDG targets for 2030.

METHODS

Study design

We applied the Child Health and Nutrition Research Initiative (CHNRI) methodology for setting research priorities in health [11]. The CHNRI method was designed to assist policy–makers and investors in identifying research gaps and examining the potential risks and benefits of investing in different research options. This systematic and transparent approach has now been applied to a wide range of topics, including but not limited to: birth asphyxia, childhood pneumonia and diarrhea, and integrated community case management [12-15]. The CHNRI method involves five stages: (i) defining the context and criteria for priority–setting with input from investors and policy–makers; (ii) listing and scoring of research investment options by technical experts using the proposed criteria; (iii) weighing the criteria according to wider societal values with input from other stakeholders; (iv) calculating research priority scores and average expert agreement scores; and (v) setting research priorities according to research priority scores.

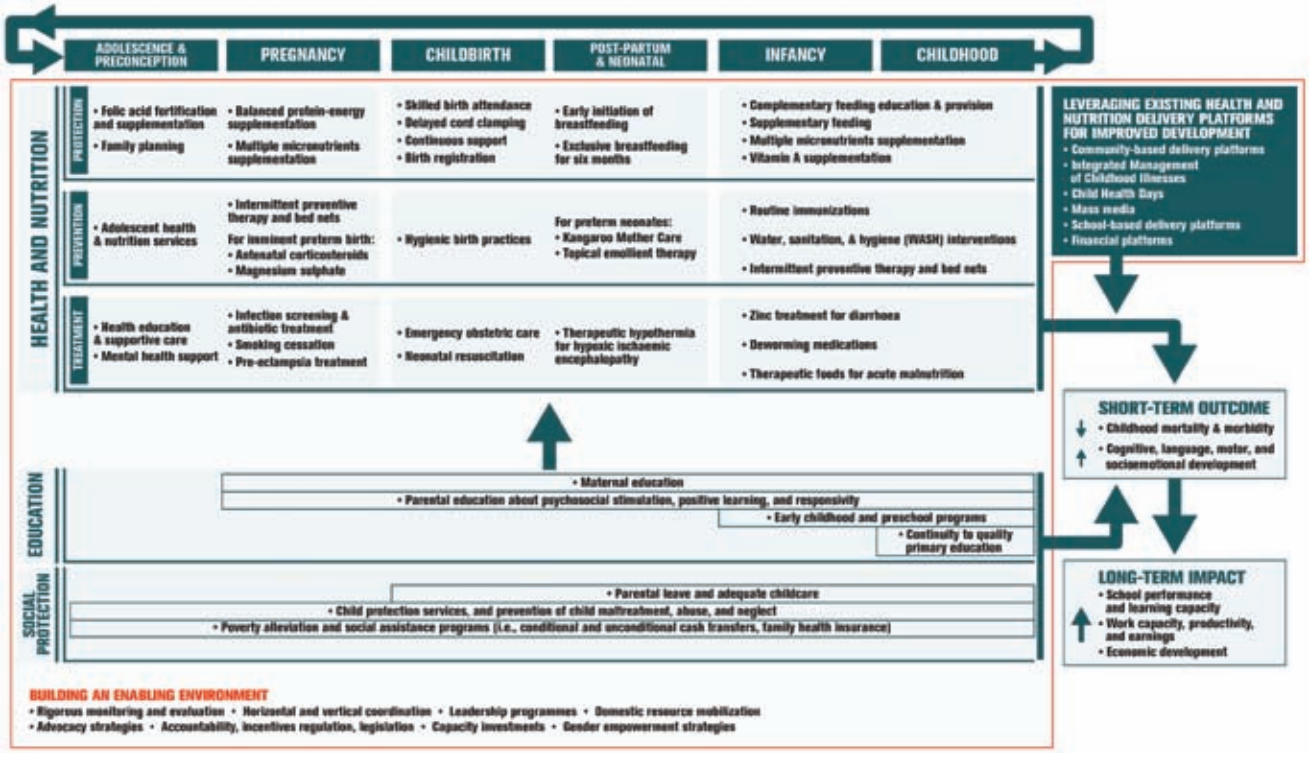


Figure 1. Pathway from interventions to improved human development.

Stage 1. Define the context and criteria for priority–setting

The aim of this expert consensus process was to inform key global donors/investors in health research, and researchers about research investment options and priority questions that might improve development, health and well-being across the life course in the most integrated and effective way. This process of developing and ranking research questions also allowed researchers to systematically approve a common research agenda and develop a consensus on priorities. We applied the five CHNRI criteria to evaluate proposed research questions: (i) answerability; (ii) effectiveness; (iii) deliverability; (iv) impact; and (v) effect on equity [11]. **Table 1** displays the three specific sub–questions under each criterion used to evaluate the research questions.

Stage 2. Technical experts list and score research options using predetermined criteria

We targeted a purposive sample of researchers and program experts from both high–income countries and LMICs, with expertise in ECD and/or MNCAH&N. This sample included authors of relevant Lancet series and known experts in these fields globally. In total, 67 experts were formally invited to participate in the exercise, of which 32 experts agreed. Fifteen experts provided both research questions and scores, 12 participants provided only questions, and 5 participants provided only scores. From the 27 participants who provided research questions, 92 questions were proposed. The steering committee compiled the questions, removing overlapping options and questions that fell outside the scope of the exercise. The 27 participants mentioned above were then given an opportunity to review the consolidated list before the questions were organized into a marking tool for scoring. The final scorecard contained 57 research questions (Appendix S1 in **Online Supplementary Document**) that were scored by 20 participants.

Table 1. Child Health and Nutrition Research Initiative (CHNRI) criteria

Criterion	Sub–questions
Answerability:	
	1. Would you say the research question is well framed and endpoints are well defined?
	2. Based on: (i) the level of existing research capacity in proposed research and (ii) the size of the gap from current level of knowledge to the proposed endpoints; would you say that a study can be designed to answer the research question and to reach the proposed endpoints of the research?
	3. Do you think that a study needed to answer the proposed research question would obtain ethical approval without major concerns?
Effectiveness:	
	1. Based on the best existing evidence and knowledge, would the intervention which would be developed/improved through proposed research be efficacious?
	2. Based on the best existing evidence and knowledge, would the intervention which would be developed/improved through proposed research be effective?
	3. If the answers to either of the previous two questions are positive, would you say that the evidence upon which these opinions are based is of high quality?
Deliverability:	
	1. Taking into account the level of difficulty with intervention delivery from the perspective of the intervention itself (eg, design, standardizability, safety), the infrastructure required (eg, human resources, health facilities, communication and transport infrastructure) and users of the intervention (eg, need for change of attitudes or beliefs, supervision, existing demand), would you say that the endpoints of the research would be deliverable within the context of interest?
	2. Taking into account the resources available to implement the intervention, would you say that the endpoints of the research would be affordable within the context of interest?
	3. Taking into account government capacity and partnership requirements (eg, adequacy of government regulation, monitoring and enforcement; governmental intersectoral coordination, partnership with civil society and external donor agencies; favorable political climate to achieve high coverage), would you say that the endpoints of the research would be sustainable within the context of interest?
Impact:	
	1. Will the results of this research fill an important knowledge gap?
	2. Are the results from this research likely to shape future planning and implementation?
	3. Will the results of this research lead to a significant and measurable reduction in disease burden?
Effect on equity:	
	1. Would you say that the present distribution of the disease burden affects mainly the underprivileged in the population?
	2. Would you say that the underprivileged would be the most likely to benefit from the results of the proposed research after its implementation?
	3. Would you say that the proposed research has the overall potential to improve equity in disease burden distribution in the long term (eg, 10 y)?

Experts scored each proposed research question against these five predetermined criteria, each with three sub–questions:

- **Answerability:** likelihood that the research question could be answered ethically.
- **Effectiveness:** likelihood that the intervention developed through the proposed research would be efficacious and effective.
- **Deliverability:** likelihood that the endpoints of the research would be deliverable, affordable and sustainable.
- **Impact:** likelihood that the results from this research would fill crucial knowledge gaps, shape future planning and implementation, and significantly reduce the burden of disease.
- **Effect on equity:** likelihood that the research would reduce inequity.

For each of the 15 sub–questions, we asked experts to score 1 for yes, 0 for no and 0.5 if they were informed but undecided. If the experts did not perceive themselves as sufficiently knowledgeable to answer a particular question, they were instructed to leave the cell blank. These blank cells were not included in the calculation of scores. Twenty experts returned completed scoring sheets.

Stage 3. Solicit input from societal stakeholders to weigh the criteria

The relative importance of the scoring criteria may vary among stakeholders. In a previous exercise, a wide range of stakeholders was polled to weigh the CHNRI criteria [16]; however, prior to scoring, the steering committee decided not to assign weights for the present exercise. We scored all five criteria equally in the analysis, as we felt they were of equal importance.

Stage 4. Calculation of research priority scores and average expert agreement

The research priority score and average expert agreement score were calculated for each of the 57 research questions. The research priority score is the mean of the scores across the five criteria, expressed as a percentage. The average expert agreement score is the average proportion of scorers who chose the mode (most common score) across the 15 sub–questions asked. The average expert agreement score was calculated as follows:

$$AEA = \frac{1}{15} \times \sum_{q=1}^{15} \frac{\text{N(scorers who provided the most frequent response)}}{\text{N(scorers)}}$$

where q is a question that experts are being asked to evaluate competing research investment options, ranging from 1 to 15. A Pearson correlation coefficient was calculated to examine the association between research priority score and average expert agreement scores.

Ethics statement

A formal ethics review was not required as the work did not involve any personal or otherwise sensitive data and participants provided input within their professional capacity. A positive response to the invitation email indicated consent to participate in the exercise.

RESULTS

Of the 27 experts that proposed research questions, approximately 26% were based in LMICs in Africa, Asia, and South America, 19% were program experts, 70% were researchers, and 11% were involved in both research and programing. In contrast, 25% of the 20 respondents who provided scores from LMICs, 5% were program experts, 85% were researchers, and 10% were involved in both. The characteristics of the study participants are summarized in **Figure 2**.

The scorecard contained 855 fields in total, and across the 20 scorecards returned, experts completed an average of 76.3% (652.4) of fields. **Table 2** shows the 23 research questions with a research priority score above 85.00, and Annex I includes the complete list of ranks and scores for all 57 questions. Both tables present the perceived likelihood that each research question will comply with each of the five chosen priority–setting criteria. The research priority scores ranged from 61.01 to 93.52, with a median of 82.87. The average expert agreement scores ranged from 0.50 to 0.90, with a median of 0.75. Similar to past CHNRI exercises, average expert agreement showed a strong positive association with research priority

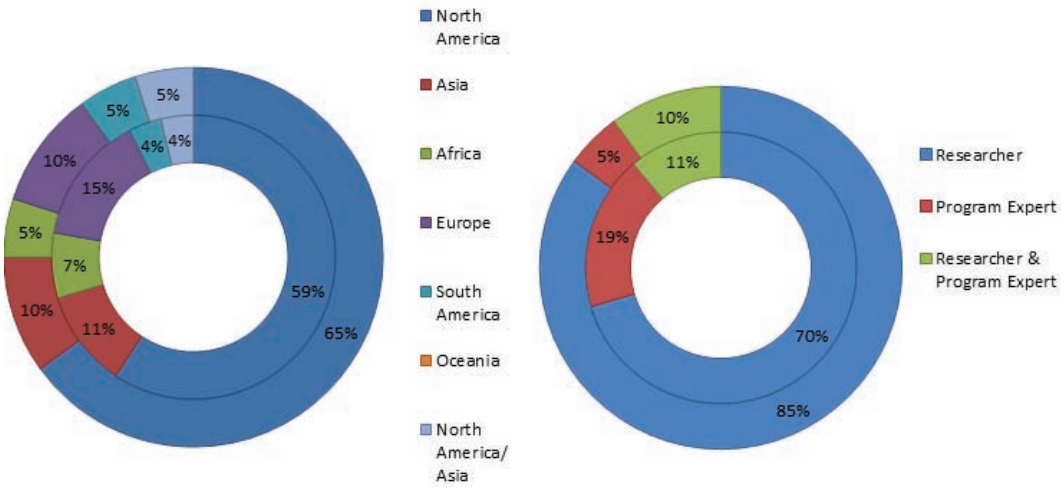


Figure 2. Background characteristics of respondents. The inner graphs indicate characteristics of the 27 experts who proposed research questions. The outer graphs indicate characteristics of the 20 experts who provided scores.

score, as evidenced by a Pearson correlation coefficient of 0.967 ($P<0.0001$). This finding indicates that there was strong agreement among experts about what were considered priority research questions.

The 3 top–ranked research questions were: i) "How can interventions and packages to reduce neonatal mortality be expanded to include ECD and stimulation interventions?"; ii) "How does the integration of ECD and MNCAH&N interventions affect human resource requirements and capacity development in resource–poor settings?"; and iii) "How can integrated interventions be tailored to vulnerable refugee and migrant populations to protect against poor ECD and MNCAH&N outcomes?". The fourth highest–ranked question – 'What are the benefits, if any, of linking ECD programs with microcredit or conditional cash transfer programs?' – received a perfect score for the effect on equity criterion.

The 23 highest–ranked questions varied across the continuum of care, with explicit mention of all populations of interest: neonates (question #1), infants and children (#5, 6, 10, 12, 17, 20, 23), adolescents (#7), and mothers (#19, 20, 23). There was also a particular emphasis on at–risk populations, including: refugees and migrant workers (#3), small for gestational age infants (#5), children with nutritional and cognitive deficits (#10), and mothers and children vulnerable to violence (#20, 23). Moreover, research questions pertaining to capacity development and responsibilities of community health workers (#2, 8, 11), responsive and complementary feeding (#6, 14), and cost–effectiveness and financial incentive programs (#4, 18, 22) were identified as top priorities. Mobile phones and media were proposed as a potential delivery platform for integrated interventions (#15), and there were two highly ranked research questions about determining the parameters for quality assessment of integrated programs (#13, 17).

DISCUSSION

The present exercise engaged a diverse group of global health experts with knowledge and experience across the continuum of care for MNCAH&N strategies as well as ECD relevant interventions and delivery platforms. The CHNRI method's systematic ranking of proposed research priorities against predetermined criteria made apparent some of the strengths and weaknesses of competing research investment options, and offered greater replicability and transparency than Delphi or other consultative processes [17].

The research question that received the highest research priority score pertained to the integration of ECD packages to interventions to reduce neonatal mortality. Programs that address neonatal mortality and morbidity provide an opportunity to intervene early to optimize development, and thus fulfill a major principle in addressing risks to child development. Moreover, the comprehensive list of highly–ranked

Table 2. Top 23 research questions according to their achieved research priority score, with average expert agreement related to each question

Rank	Research Question	Criterion 1: Answerability	Criterion 2: Effectiveness	Criterion 3: Deliverability	Criterion 4: Impact	Criterion 5: Effect on equity	RPS	AEA
1	How can interventions and packages to reduce neonatal mortality be expanded to include ECD and stimulation interventions?	0.96	0.88	0.95	0.95	0.93	93.52	0.90
2	How does the integration of ECD and MNCAH&N interventions affect human resource requirements and capacity development in resource–poor settings?	0.94	0.86	0.91	0.94	0.94	91.77	0.86
3	How can integrated interventions be tailored to vulnerable refugee and migrant populations to protect against poor ECD and MNCAH&N outcomes?	0.94	0.83	0.84	0.95	0.97	90.81	0.87
4	What are the benefits, if any, of linking ECD programs with microcredit or conditional cash transfer programs?	0.94	0.88	0.79	0.93	1.00	90.69	0.85
5	How can sensory stimulation best be integrated with nutrition interventions for small for gestational age infants to significantly improve their developmental outcomes over the long–term?	0.97	0.87	0.83	0.93	0.90	90.04	0.84
6	Do responsive feeding interventions promote children's cognitive and socio–emotional development?	0.95	0.84	0.95	0.87	0.89	89.96	0.81
7	What is the most effective approach for implementing integrated ECD and MNCAH&N interventions aimed at adolescent girls?	0.95	0.81	0.88	0.94	0.88	89.01	0.82
8	What are the key elements required in the design of effective national ECD workforce development and retention strategies across diverse socio–economic and cultural contexts?	0.83	0.88	0.82	0.93	0.97	88.31	0.81
9	What are potential barriers to scale up of integrated MNCAH&N and ECD interventions in low and middle–income countries?	0.89	0.79	0.95	0.88	0.89	87.82	0.82
10	For children who have endured either nutritional or cognitive deprivation in the first 1000 d from conception, is it possible to improve ECD outcomes with or without affecting linear growth?	0.90	0.79	0.88	0.91	0.91	87.73	0.79
11	What is the feasibility of integrating ECD interventions into the responsibilities of community health workers, and what specific interventions should be prioritized?	0.87	0.87	0.82	0.89	0.93	87.68	0.82
12	What are effective approaches for supporting parents of young children (under 6 y) to adopt integrated practices that promote child nutrition, health and development?	0.84	0.86	0.82	0.93	0.92	87.39	0.77
13	What are the parameters for assessing the quality of integrated ECD and MNCAH&N programs?	0.88	0.85	0.92	0.88	0.83	87.32	0.80
14	Does the promotion of high quality, timely complementary feeding in ECD and MCHN activities actually translate into improved practice?	0.94	0.86	0.82	0.85	0.89	87.13	0.77
15	How can mobile phones and/or media be most effectively utilized as a delivery platform for integrated ECD and MNCAH&N interventions?	0.92	0.82	0.90	0.89	0.82	86.82	0.80
16	Who is the most feasible and acceptable delivery agent of integrated interventions in low resource community–based settings?	0.82	0.82	0.90	0.90	0.90	86.72	0.80
17	Develop and validate measures of quality and coverage of integrated ECD and nutrition interventions in early infancy and childhood.	0.92	0.83	0.88	0.89	0.81	86.70	0.82
18	Where are the gaps in financing programs that aim to integrate and support ECD and MNCAH&N?	0.91	0.84	0.77	0.86	0.92	85.98	0.78
19	How can maternal health interventions to improve postpartum depression be most effectively integrated with ECD programs?	0.95	0.88	0.83	0.86	0.78	85.78	0.76
20	How can intervention strategies on the prevention of violence against mothers and children be most effectively integrated with ECD programs?	0.92	0.79	0.86	0.89	0.82	85.51	0.78
21	What are the critical windows along the continuum of care in which MNCAH&N and ECD interventions can most effectively and feasibly be integrated?	0.75	0.95	0.78	0.94	0.86	85.42	0.80
22	What is the feasibility and cost–effectiveness of different models of scaling up integrated ECD and MNCAH&N interventions in resource–limited settings?	0.86	0.78	0.78	0.95	0.90	85.32	0.77
23	What is the impact of integrating intervention strategies on the prevention of violence against mothers and children with ECD programs?	0.92	0.84	0.77	0.88	0.85	85.07	0.75

*RPS – research priority score; AEA – average expert agreement; ECD – early childhood development; MNCAH&N – maternal, newborn, child and adolescent health & nutrition

research priorities also highlighted key elements of scaling up coverage of integrated interventions in LMICs, including: human resource and capacity development, cost–effectiveness and incentive schemes to reduce financial barriers, and quality assessment of integrated health programing. These three central themes, along with questions about harnessing the capacity of information technology and mobile health platforms, feature heavily across implementation–focused CHNRIs, indicating strong agreement that they are priority implementation challenges in global health [15,18,19].

Although the CHNRI method represents a systematic attempt to address the challenges inherent in the complex process of research investment priority setting, the approach is not without limitations. Yoshida and colleagues conducted an analysis of the CHNRI methodology [20], examining the concordance among top ranking research priorities as sample size increases from 15 to 90. They found that a high degree of reproducibility of top ranking research priorities was achieved with 45–55 experts, suggesting that our relatively small sample of 20 scorers may be a limitation. However, it should be noted that they still observed an appreciable degree of reproducibility with a sample size of only 15 persons. An additional potential limitation of the present study is the possibility that there were sound research options that were not included in the list of questions generated by experts. These options, therefore, could not have been scored and identified as priorities. It is also possible that the list of highly–ranked research priorities might have been different if there was greater representation of program experts or policy makers; for instance, they may have provided more detailed questions pertaining to their specific implementation challenges. Proposed research questions and their subsequent scores were limited to the opinions of the experts involved in the exercise. In an effort to minimize response bias, we employed a comprehensive process of identifying experts with relevant knowledge to participate in the study. The predetermined CHNRI criteria also ensured that questions were anonymously scored against a transparent and standardized set of values; thus, eliminating the advantage of more eloquent speakers advocating for their own research agenda. Lastly, experts might have scored questions about patient populations, interventions or health conditions outside of their area of expertise. To avoid inaccurate scores, experts were instructed to leave the cell blank when they did not feel sufficiently knowledgeable to answer a particular question.

The top–ranked research questions addressing capacity development and retention strategies reflect the current global shortage of skilled health workers with the ability to implement integrated ECD and MNCAH&N interventions. This finding is highly consistent with what others have previously identified as a top priority of scaling up integrated ECD programs [21,22], lending further credibility to our results. Collectively, the 75 countries with more than 95% of the current burden of maternal and child mortality have an estimated median of 10.2 physicians, nurses and midwives per 10 000 people, and three–quarters are below the World Health Organization benchmark of 22.8 per 10 000 [1]. Task–shifting has been successfully implemented in several countries to increase access to essential interventions. Community health workers are well positioned to respond to local cultural and societal norms and to foster the acceptability and uptake of integrated interventions. However, it has been argued that a potential disadvantage of integrating programs is the risk of overloading health services and reducing their effectiveness [23]. Hence, question eleven – "What is the feasibility of integrating ECD interventions into the responsibilities of community health workers, and what specific interventions should be prioritized?" – is especially critical to inform the integration debate.

Three highly–ranked questions related to the financial aspects of integrated implementation; in particular, assessing the cost–effectiveness of different delivery models, identifying financing gaps, and linking ECD programs with microcredit or conditional cash transfer programs. Support platforms that provide direct or indirect monetary incentives to households have been employed for decades in Latin America and Sub–Saharan Africa, and more recently, in South Asia [24]. Such financial incentive programs are widely implemented strategies to improve health inequities and have been shown to alleviate poverty, improve access to health services, and scale up intervention coverage. These programs, such as conditional cash transfers, also facilitate the uptake of specific interventions and behaviors such as immunizations, care seeking and nutrition interventions. They can also offer exceptional opportunities to help families partake in platforms and interventions to promote health, nutrition and ECD interventions.

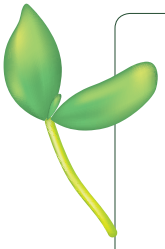
Quality assessment of integrated programs was the central theme of two highly ranked research questions. A disproportionately high burden of mortality and morbidity is observed among poor, rural, and remote communities with limited access to quality health services [25]. Culturally–informed quality assessments are thus an important component of the monitoring and accountability agenda. Timely data on the quality and coverage of essential interventions is necessary for recognizing and reducing inequities, as well as understanding which programs are working and why. The identified research questions could feed into

the Measuring Early Learning Quality and Outcomes project (MELQO) – convened by UNICEF, UNESCO, the World Bank and the Center for Universal Education at the Brookings Institute. This initiative is pulling together expertise on measurement from around the world to produce feasible, efficient and accurate approaches to the measurement of the quality of ECD programs and children's learning environments.

In a recent CHNRI exercise focused solely on ECD, all top–ranked priorities related to the impact of implementation of interventions, with three priorities pertaining specifically to integration of ECD and maternal, newborn, and child health and nutrition services [26]. This finding underscores the importance of examining integrated implementation, and the present study expands on this broader ECD research agenda, indicating specific priority areas for accelerated research.

To our knowledge, there has been one other CHNRI that has explored implementation research priorities across the entire continuum of MNCAH&N and, like the present exercise, children were the most represented target population [18]. This focus on children could be because early childhood, particularly the first 1000 days, has the greatest potential for gains in health, growth and development [27]. However, what is novel in our research agenda compared with other implementation–focused CHNRIs is the mention of specific at–risk populations, such as refugees and migrant workers, children with nutritional and cognitive deficits, and mothers and children susceptible to violence. These populations are most vulnerable to adversity exposures and are therefore, most likely to benefit from increased access to ECD interventions via integrated delivery. Although high–risk populations were mentioned, we noted there were no questions targeting conflict and humanitarian settings – where disruptions in the health care infrastructure and exposure to stress, violence, food insecurity, and child neglect are greatest. The same applies to refugees and displaced populations, despite the latter now numbering in the millions, especially in the wake of the incessant conflict in the Middle East. This gap in the identified research priorities was potentially a result of limited expertise in this area among the respondents, and it must be acknowledged given the disproportionate burden of poor ECD in fragile states.

Investing in ECD is critical to achieving a number of SDGs [6], including SDG 3 [2], which aims to ensure health and well–being for all, and SDG 4, which aims to ensure inclusive and equitable quality education and promote life–long learning opportunities for all. The integration of delivery platforms presents an opportunity to maximize the impact of health and development interventions within sensitive windows across the life course, thereby reducing pervasive inequities that exist both within and across communities. The generated research agenda is expected to be a valuable tool that drives discussion on mainstreaming implementation research on integration of ECD interventions with the health and nutrition sectors. We call upon the global community of donors, researchers, policy–makers and program managers to advocate for the breakdown of siloes between health, nutrition, education, social protection and ECD initiatives; to support the translation of these recommendations into appropriate and transparent funding opportunities; and in doing so, to actively work toward enabling the sustainable and inclusive development of societies.



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Authorship declaration:RS designed the study protocol, coordinated the study, conducted the analysis, drafted the initial manuscript, and made subsequent revisions. MG designed the study protocol, and critically reviewed and revised the manuscript. ZB conceptualized and designed the study, oversaw the Child Health and Nutrition Research Initiative process, and critically reviewed and revised the manuscript. HA, DG, KB, GLD, JKD, JEdeG-J, JDH, SH, LH, JH, SL, RPE, KP, KM, VMH, MSM, AR, KL, DRS, and PW generated and scored priority research questions, provided feedback during the study, and critically reviewed and revised the manuscript.

Competing interests: The authors completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available upon request from the corresponding author), and declare no conflict of interest.

1 UNICEF, World Health Organization. A decade of tracking progress for maternal, newborn and child survival: the 2015 report – countdown to 2015. Available: http://countdown2030.org/documents/2015Report/Countdown_to_2015_final_report.pdf. Accessed: 13 June 2016.

2 United Nations. Resolution adopted by the General Assembly: 70/1. Transforming our world: the 2030 Agenda for Sustainable Development. 2015. Available: www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1. Accessed: 25 September 2015.

3 Grantham-McGregor S, Cheung YB, Cueto S, Glewwe P, Richter L, Strupp B, et al. Developmental potential in the first 5 years for children in developing countries. Lancet. 2007;369:60-70. Medline:17208643 doi:10.1016/S0140-6736(07)60032-4

4 Black MM, Walker SP, Fernald LCH, Andersen CT, DiGirolamo AM, Lu C, et al. Early Child Development coming of age: science through the life-course. Lancet. 2017;389:77-90. Medline:27717614 doi:10.1016/S0140-6736(16)31389-7

5 McCoy DC, Peet ED, Ezzati M, Danaei G, Black MM, Sudfeld CR, et al. Early childhood developmental status in low- and middle-income countries: national, regional, and global prevalence estimates using predictive modeling. PLoS Med. 2016;13:e1002034. Medline:27270467 doi:10.1371/journal.pmed.1002034

6 Richter LM, Daelmans B, Lombardi J, Heymann J, Boo FL, Behrman JR, et al. Investing in the foundation of sustainable development: pathways to scale-up for Early Child Development. Lancet. 2017;389:103-18. Medline:27717610 doi:10.1016/S0140-6736(16)31698-1

7 Vaivada T, Gaffey MF, Bhutta ZA. Promoting Early Child Development with interventions in health and nutrition: a systematic review. Pediatrics. Forthcoming 2017.

8 Black RE, Victora CG, Walker SP, Bhutta ZA, Christian P, de Onis M, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. Lancet. 2013;382:427-51. Medline:23746772 doi:10.1016/S0140-6736(13)60937-X

9 Hamadani JD, Nahar B, Huda SN, Tofail F. Integrating early child development programs into health and nutrition services in Bangladesh: benefits and challenges. Ann N Y Acad Sci. 2014;1308:192-203. Medline:24571219 doi:10.1111/nyas.12366

10 Grantham-McGregor SM, Fernald LCH, Kagawa RMC, Walker S. Effects of integrated child development and nutrition interventions on child development and nutritional status. Ann N Y Acad Sci. 2014;1308:11-32. Medline:24673166 doi:10.1111/nyas.12284

11 Rudan I, Gibson JL, Ameratunga S, El Arifeen S, Bhutta ZA, Black M, et al. Setting priorities in global child health research investments: guidelines for implementation of the CHNRI method. Croat Med J. 2008;49:720-33. Medline:19090596 doi:10.3325/cmj.2008.49.720

12 Lawn JE, Bahl R, Bergstrom S, Bhutta ZA, Darmstadt GL, Ellis M, et al. Setting research priorities to reduce almost one million deaths from birth asphyxia by 2015. PLoS Med. 2011;8:e1000389. Medline:21305038 doi:10.1371/journal.pmed.1000389

13 Rudan I, El Arifeen S, Bhutta ZA, Black RE, Brooks A, Chan KY, et al. Setting research priorities to reduce global mortality from childhood pneumonia by 2015. PLoS Med. 2011;8:e1001099. Medline:21980266 doi:10.1371/journal.pmed.1001099

14 Wazny K, Zipursky A, Black R, Curtis V, Duggan C, Guerrant R, et al. Setting research priorities to reduce mortality and morbidity of childhood diarrhoeal disease in the next 15 years. PLoS Med. 2013;10:e1001446. Medline:23690756 doi:10.1371/journal.pmed.1001446

15 Wazny K, Sadruddin S, Zipursky A, Hamer DH, Jacobs T, Kallander K, et al. Setting global research priorities for integrated community case management (iCCM): results from a CHNRI (Child Health and Nutrition Research Initiative) exercise. J Glob Health. 2014;4:020413. Medline:25520803 doi:10.7189/jogh.04.020413

16 Kapiriri L, Tomlinson M, Chopra M, El Arifeen S, Black RE, Rudan I, et al. Setting priorities in global child health research investments: addressing values of stakeholders. Croat Med J. 2007;48:618-27. Medline:17948948

17 Yoshida S. Approaches, tools and methods used for setting priorities in health research in the 21st health century. J Glob Health. 2016;6:010507. Medline:26401271

18 Sharma R, Buccioni M, Gaffey MF, Mansoor O, Scott H, Bhutta ZA, et al. Setting an implementation research agenda for Canadian investments in global maternal, newborn, child and adolescent health: a research prioritization exercise. CMAJ Open. 2017;5:E82-9. Medline:28401123 doi:10.9778/cmajo.20160088

19 GAPPS Expert Group on Community Based Strategies and Constraints, George A, Young M, Bang A, Chan KY, Rudan I, et al. Setting implementation research priorities to reduce preterm births and stillbirths at the community level. PLoS Med. 2011;8:e1000380. Medline:21245907 doi:10.1371/journal.pmed.1000380

20 Yoshida S, Rudan I, Cousens S. Setting health research priorities using the CHNRI method: VI. Quantitative properties of human collective opinion. J Glob Health. 2016;6:010503. Medline:27350874 doi:10.7189/jogh.06.010503

21 Black MM, Pérez-Escamilla R, Rao SF. Integrating nutrition and child development interventions: scientific basis, evidence of impact, and implementation considerations. Adv Nutr. 2015;6:852-9. Medline:26875208 doi:10.3945/an.115.010348

22 Yousafzai AK, Rasheed MA, Daelmans B, Manji S, Arnold C, Lingam R, et al. Capacity building in the health sector to improve care for child nutrition and development. Ann N Y Acad Sci. 2014;1308:172-82. Medline:24571217 doi:10.1111/nyas.12322

23 Pallas SW, Minhas D, Pérez-Escamilla R, Taylor L, Curry L, Bradley EH. Community health workers in low- and middle-income countries: what do we know about scaling up and sustainability? Am J Public Health. 2013;103:e74-82. Medline:23678926 doi:10.2105/AJPH.2012.301102

24 Bassani DG, Arora P, Wazny K, Gaffey MF, Lenters L, Bhutta ZA. Financial incentives and coverage of child health interventions: a systematic review and meta-analysis. BMC Public Health. 2013;13:S30. Medline:24564520 doi:10.1186/1471-2458-13-S3-S30

25 UNICEF. Committing to Child Survival: A Promise Renewed, Progress Report 2015. 2015. Available: https://www.unicef.org/publications/index_83078.html. Accessed: 13 June 2016.

26 Dua T, Tomlinson M, Tablante E, Britto P, Yousfzai A, Daelmans B, et al. Global research priorities to accelerate early child development in the sustainable development era. Lancet Glob Health. 2016;4:e887-9. Medline:27717631 doi:10.1016/S2214-109X(16)30218-2

27 Bryce J, Coitinho D, Darnton-Hill I, Pelletier D, Pinstrup-Andersen P; Maternal and Child Undernutrition Study Group. Maternal and child undernutrition: effective action at national level. Lancet. 2008;371:510-26. Medline:18206224 doi:10.1016/S0140-6736(07)61694-8

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Setting research priorities for maternal, newborn, child health and nutrition in India by engaging experts from 256 indigenous institutions contributing over 4000 research ideas: a CHNRI exercise by ICMR and INCLEN

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Background Health research in low– and middle– income countries (LMICs) is often driven by donor priorities rather than by the needs of the countries where the research takes place. This lack of alignment of donor's priorities with local research need may be one of the reasons why countries fail to achieve set goals for population health and nutrition. India has a high burden of morbidity and mortality in women, children and infants. In order to look forward toward the Sustainable Development Goals, the Indian Council of Medical Research (ICMR) and the INCLEN Trust International (INCLEN) employed the Child Health and Nutrition Research Initiative's (CHNRI) research priority setting method for maternal, neonatal, child health and nutrition with the timeline of 2016–2025. The exercise was the largest to–date use of the CHNRI methodology, both in terms of participants and ideas generated and also expanded on the methodology.

Methods CHNRI is a crowdsourcing–based exercise that involves using the collective intelligence of a group of stakeholders, usually researchers, to generate and score research options against a set of criteria. This paper reports on a large umbrella CHNRI that was divided into four theme–specific CHNRIs (maternal, newborn, child health and nutrition). A National Steering Group oversaw the exercise and four theme–specific Research Sub–Committees technically supported finalizing the scoring criteria and refinement of research ideas for the respective thematic areas. The exercise engaged participants from 256 institutions across India – 4003 research ideas were generated from 498 experts which were consolidated into 373 research options (maternal health: 122; newborn health: 56; child health: 101; nutrition: 94); 893 experts scored these against five criteria (answerability, relevance, equity, innovation and out–of–box thinking, investment on research). Relative weights to the criteria were assigned by 79 members from the Larger Reference Group. Given India's diversity, priorities were identified at national and three regional levels: (i) the Empowered Action Group (EAG) and North–Eastern States; (ii) States and Union territories in Northern India (including West Bengal); and (iii) States and Union territories in Southern and Western parts of India.

Conclusions The exercise leveraged the inherent flexibility of the CHNRI method in multiple ways. It expanded on the CHNRI methodology enabling analyses for identification of research priorities at national and regional levels. However, prioritization of research options are only valuable if they are put to use, and we hope that donors will take advantage of this prioritized list of research options.

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"Today's health research is tomorrow's health service" [1]. If the research agenda is not aligned to local needs and context, it can perpetuate disharmony, inequity and inefficiency in health services and contribute to lack of attainment of policy goals [2,3]. Given that the scope of research in health and nutrition is ever–expanding and far exceeds the available resources, relative prioritization among competing research options is imperative. This is difficult, liable to subjectivity and vulnerable to being funder–driven [4]. Prioritization using a systematic, transparent, objective and inclusive process could help policy makers and research funding agencies in making their investment decisions more co–aligned, efficient and impactful [2].

The 10–90 report of the Commission on Health Research for Development (1990) emphasized on the prevailing mismatch between local health research needs and the quantum and patterns of fund allocation, particularly in low– and middle– income countries (LMICs) [5]. Between 1990 and 2005, following the 10–90 report, several attempts were made at developing structured and objective methods to identify priorities. Prominent among these, were: (i) the Ad Hoc Committee on Health Research Relating to Future Intervention Options, 1996; (ii) The Council on Health Research and Development (COHRED); (iii) the Essential National Health Research and Priority Setting (ENHR), 1996–2000; (iv) The Grand Challenges in Global Health in 2003; and, (v) the Combined Approach Matrix (CAM) tool by the Global Forum for Health Research, 1999–2004 [3,6]. In 2006–07, the Child Health and Nutrition Research Initiative (CHNRI), informed by weaknesses in existing processes, developed a flexible yet systematic method for setting research priorities, called the CHNRI method. The CHNRI method has become increasingly popular and to date, over 50 CHNRI research priority setting exercises have been reported [7]. This method recognizes research priority setting as a multi–dimensional and multi–stakeholder decision–making process. It balances immediate contextual translational needs (the 'delivery' and 'development' instruments of research) with need for generation of new knowledge through long–term investment ("description" and "discovery"). The CHNRI method systematically delegates, ie, "crowdsources," [8] the task of prioritization to the various constituencies of stakeholders (end–users of health research funding) [9]. Crowdsourcing is the use of collective wisdom or collective tasks for the benefit of an individual and or an organization, such as to solve a problem or complete a task [10]. The CHNRI method has been shown to be effective at the national level wherein input from local stakeholders can influence research investment policies [11].

India is the second most populous country in the world with many pressing health problems that, in fact, hugely determine the global health statistics. Maternal, neonatal, child health and nutrition (MNCHN) together contribute to the largest burden of disease in India. Public health research decisions in India have traditionally been guided by a small group of experts who are located mostly in the metropolis and are constrained by individual and organizational preferences. In 2011, in response to the seemingly unachievable Millennium Development Goals 4 and 5 (MDG4, MDG5), National Health Mission goals, and the upcoming Sustainable Development Goals 2030, the Indian Council for Medical Research (ICMR; the apex institution for medical research in India) and the INCLEN Trust International (INCLEN; which was the CHNRI Secretariat since 2010) came together to undertake this nationwide research priority setting exercise for MNCHN using the CHNRI methodology. Newborns, children (0–18 years), and reproductive age women (15–49 years, including pregnant women and lactating mothers) were identified to be the target population for prioritization along the life–course continuum. India has large population diversity along with regional– and state–level heterogeneity in governance, program performance, socio–cultural milieu and economics. Hence, it was decided that research priorities would be identified at national and sub–national (regional) levels with a 10–year reference time period (2016–2025) and through inclusion of a large number of stakeholders for representativeness.

METHODS

The ICMR–INCLEN National Research Priority Setting (RPS) exercise was completed between 2012 and 2016. The exercise was coordinated by the RPS project management team at the Executive Office of INCLEN, New Delhi. The team had experts in the four core MNCHN disciplines (pediatrics, obstetrics and gynecology, community medicine, and public health nutrition) and was multilingual and hence, able to communicate and engage participants from across the country.

States and union territories were grouped into three regions in order to enable sub–national priorities. The three regions were: (i) Empowered Action Group (EAG) States (Rajasthan, Madhya Pradesh, Chattisgarh, Odisha, Jharkhand, Bihar, Uttar Pradesh and Uttarakhand) and North–Eastern (NE) States (Sikkim, Assam, Meghalaya, Tripura, Mizoram, Manipur, Nagaland, Arunachal Pradesh); (The Government

of India has identified eight states with poor health and development indicators as EAG states for focused action. EAG and NE states share similarities in MNCHN contexts and program performance); (ii) Northern states and Union territories (Jammu & Kashmir, Punjab, Himachal Pradesh, Haryana, Chandigarh, Delhi, and West Bengal); and (iii) States and Union Territories in Southern and Western part of the country (Kerala, Tamil Nadu, Karnataka, Andhra Pradesh and Telangana, Maharashtra, Gujarat, Goa, Puducherry).

Four key structures were created to accomplish the task, outlined as follows.

1. The National Steering Group (NSG)

The NSG was the highest body for policy making and oversight for the exercise. Its responsibilities included (i) setting the rationale and contour of the MNCHN research themes; (ii) establishment of research sub–committees (RSCs); (iii) critical review, interpretation and endorsement of the results of the exercise; and, (iv) dissemination of the final national and regional research priorities. The NSG was co–chaired by the Secretary, Department of Health Research (DHR) & Director General (DG–ICMR) and Executive Director of INCLEN. It included key officials from the Ministry of Health & Family Welfare (National Health Mission, Child Health, Maternal Health and Nutrition divisions, Directorate General of Health Services and DHR–ICMR), Ministry of Women and Child Development (Integrated Child Development Services, Food and Nutrition Board), and Ministry of Science and Technology (Department of Biotechnology, Department of Science & Technology). Its membership also included invited subject experts and representatives of national and international donors and multilateral agencies. The chairs of all four RSCs were also members of the NSG (**Table 1**). Two NSG meetings were organized – the first (on 18th April 2013), at the initiation of the exercise to ratify the context **(Box 1)** and protocol, and the second (on 4th February 2016), at the conclusion to review, refine and finalize the results.

Box 1. Context of the INCLEN ICMR national research priority setting exercise in maternal, newborn, children health and nutrition

Purpose: Priority setting in maternal, newborn, and child health and nutrition for efficient and rewarding investment in research using a systematic, transparent, inclusive, objective and quantitative method.

Target population: Women of reproductive age (15–49 years) including pregnant and lactating women, newborns (0–28 days), under–five children (0–59 months) and children up to the age of 18 years.

Geography: Priorities at National and three Regional levels: Empowered Action Group States and North–Eastern States, States and Union Territories in Norhtern India, and those in Southern and Western India.

Major areas of concern for research: Conditions that together contributed to 75% of the mortality and morbidity burden in Maternal, Newborn, Child Health and Nutrition in India during 2012–2013 as per the available evidence and expert opinion.

Time frame: For the next ten years ie, 2016–2025 (with due consideration to unachieved Millennium Development Goals 1, 4 and 5, and National Health Mission targets and the challenge of preparing the national agenda for achieving forthcoming Sustainable Development Goals 2030).

Stakeholder constituencies (operating in civil, public and private sectors, health and non–health sectors): Researchers, professionals, public health functionaries, policy makers, communities and their leadership, civil society, donor agencies and industries.

Translation and implementation context: Public and private health systems of India and their existing as well as future programs, national and international institutions & organizations funding research, research environment in academic & research institutions.

Table 1. Profile of the National Steering Group

Expertise	18 Apr 2013	4 Feb 2016
Policy–Decision Makers and Program Managers (MNCHN), Government of India	22	24
Multilateral/ Bilateral Donor Agencies/Foundation – Funders	15	19
Technical Experts (MNCHN)	29	21
State Program Managers (ICDS, NRHM, Directorate of Health Services)	9	11
Biomedical Journal Editors	3	3
Total	**78**	**78**

2. The thematic Research Sub–Committees (RSCs)

An RSC was constituted for each of the four themes. The RSCs' membership included technical experts (subject experts, basic scientists and public health specialists), social scientists, program specialists (health, and woman and child development), and donor agency representatives. Technical experts were identified through a literature search for active research contribution to respective MNCHN domains (**Table 2**). The RSCs participated in the crowdsourcing processes along with the nationwide network. They also helped in the iterative refinement and consolidation of the research options (ROs) and in finalizing the scoring criteria and their definitions. Respective RSCs presented the study findings to the second meeting of the NSG for review.

3. The Nationwide Network for crowd sourcing

A network was established with experts identified from institutions and departments across the country. Faculty/researchers from departments that were directly or indirectly engaged in work pertaining to MNCHN (eg, obstetrics & gynecology, pediatrics, neonatology, community medicine, biochemistry, physiology, pathology, microbiology, midwifery, public health nutrition and home sciences, social sciences, statistics and demography, and agriculture) were contacted through their respective institutional heads. The effort was to secure similar proportion of faculty members/researchers with more than 10 years of research or teaching experience (ie, 'senior' faculty) and those who are junior/middle level with 5–10 years of experience. National and zonal office–bearers of major professional associations in MNCHN (the Indian Academy of Pediatrics, the National Neonatology Forum, the Federation of Obstetrics and Gynecological Societies of India, the Indian Association of Preventive and Social Medicine, the Indian Public Health Association, the Nutrition Society of India, and the Indian Dietetic Association) were also contacted for participation. Central and state–level policy–makers and program managers were also invited to participate in the exercise. These were from departments of health and of women and child development. Experts were also identified through snow–balling and invitations in personal capacity.

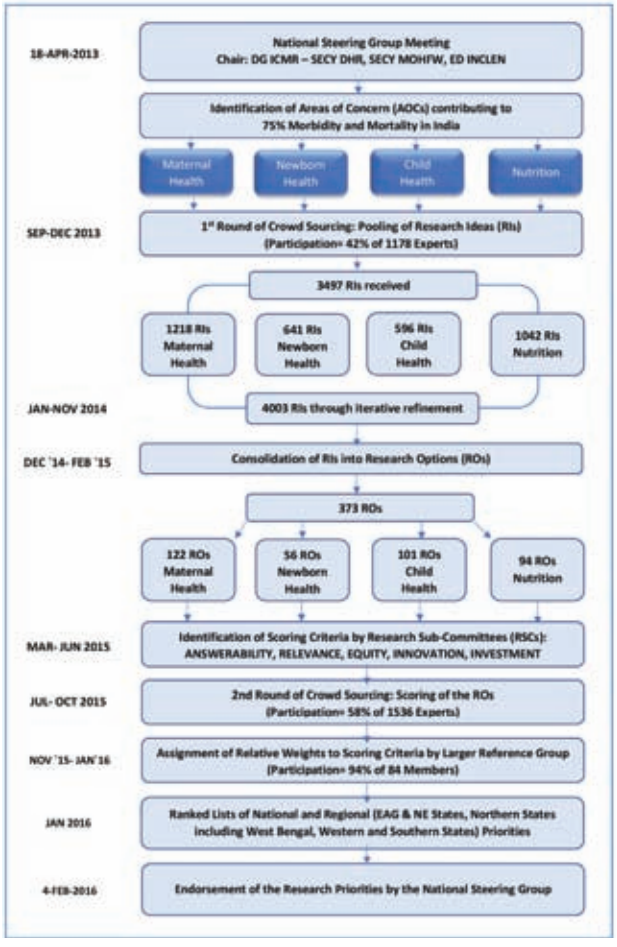

Figure 1. Sequence of activities undertaken in the ICMR–INCLEN National Research Priority Setting Exercise.

The members in the nationwide network consented to be allocated into one of the four themes according to their expertise and publication history to achieve equitable regional and disciplinary representation in each theme. In this manner, for the first round of crowd sourcing, 1423 experts (including the 112 in the RSCs) were identified, of whom 1178 could be contacted. Of these, 12 declined to participate. Of the remaining 1166 experts (**Table 2**), 668 did not respond. Overall, 498 (42.3%) experts contributed research ideas. For the second round (scoring activity), 1536 experts were contacted (including those contacted during the first round) of which 15 declined, 628 did not respond/ logged in but did not score, and 893 (58.1%) participated. Overall, 256 institutions including medical colleges, ICMR institutions, research organizations, NGOs, state health departments and donor agencies participated in the two rounds for crowdsourcing (**Table 3**).

4. The Larger Reference Group (LRG)

Beyond 75% of CHNRI exercises published have not employed a LRG (mostly due to trouble composing the group). Of those that could, most have been conducted at a national level [7]. To incorporate broader societal perspectives and values within the exercise, we employed a LRG which was composed of policy decision makers (n = 24; Central and State politicians and bureaucrats from key Ministries, eg, Health and Family Welfare, Woman and Child Development, Human Resource Development), senior researchers (n = 17), MNCHN program managers from central and state governments (n = 24) and representatives from research funding organizations (n = 19). The LRG attributed relative weights to the scoring criteria which helped to generate criteria–weighed priority ranks for the ROs.

Processes

Figure 1 shows the schematic flow of activities with timelines.

Table 2. Profile of research sub–committees and nation–wide network (1st round of crowd–sourcing)

Group	Expertise	Theme (with components)							
		Maternal health			Newborn health	Child health	Nutrition		Total
		Mortality	Morbidity	Still-births			Maternal	Child-hood	
Research Sub–Committee (RSC)	Basic scientists*		1		1			1	3
	Dietitians and nutritionists						8	9	17
	Experts from ICMR institutes			1					1
	Nursing & midwifery experts			1					1
	Obstetricians and gynecologists	7	4	4					15
	Pediatricians and neonatologists				13	13			26
	Policy makers (Government of India)*	1	1		1	2			5
	Scientists from research institutes (public health and allied sciences)*	2		2	2	2	2	1	11
	State program managers*	3	1		1	2	1	2	10
	Technical Experts from donor agencies*	3	2	1	7	7	1	2	23
	Sub-total	**16**	**9**	**9**	**25**	**26**	**12**	**15**	**112**
Nation–wide network (beyond RSCs)	Agriculturists						3	5	8
	Basic scientists*	2	2	1	1	1	1	3	11
	Community medicine experts	44	45	42	39	38	61	35	304
	Dietitians & nutritionists						33	33	66
	Experts from ICMR Institutes*	8	9	9	10	12	6	4	58
	Miscellaneous*						1		1
	Nursing & midwifery experts	3	3	3					9
	Obstetricians and gynecologists	68	74	82	1		17		242
	Pediatricians and neonatologists				111	122		47	280
	Policy Makers (Government of India)*							2	2
	Scientists from research institutes (public health and allied sciences)*	7	4	4	7	8	3	5	38
	State program managers*	4	4		4	4	3	3	22
	Technical Experts from donor agencies*				2	1	5	5	13
	Sub-total	**136**	**141**	**141**	**175**	**186**	**133**	**142**	**1054**
	Grand total	**152**	**150**	**150**	**200**	**212**	**145**	**157**	**1166**

*The experts in these categories were requested to identify their theme/ component of expertise.

Review of literature and identification of areas of concern

Extensive review of literature on burden of MNCHN related conditions was done in 2012–13 with focus on Indian data. We searched published literature (indexed and non–indexed), Government of India's policy documents and reports, program reviews and grey literature for the period of 1990 to 2012/2013. PubMed, CINAHL and Embase databases were searched. Based on the compendium of literature (available at: *www.inclentrust.org*), a draft list of "areas of concern" (AOCs) was prepared for each of the RPS themes and presented to the first meeting of the NSG for review. The AOCs accounted for conditions that collectively contributed to at least 75% of the mortality and morbidity burden in the respective theme.

The NSG suggested that maternal health encompassed three components viz., morbidity, mortality and stillbirths (most stillbirths occur in–utero and are thus are a maternal health concern). Similarly, it divided the nutrition theme into maternal and childhood nutrition components. The NSG advised to include three additional AOCs in each of the themes: "social determinants," "impact and improvement of existing composite public health packages," and "novel & innovative public health interventions." The final approved list of AOCs under the four themes is presented in **Table 4**.

The NSG also suggested that all research ideas (RIs) be segregated into the four domains of research: (i) description (burden of disease, epidemiology, etiology and risk factors, biomarkers, pathophysiological descriptions); (ii) discovery (identification of novel pathways, discovery of novel clinical and public health interventions/package, technology inventions, discoveries and innovations); (iii) delivery (health policy and systems research, including program evaluation and implementation research); and (iv) development (improving the existing intervention, ie, design, deliverability, affordability and sustainability).

Table 3. Profile of participating institutions in the Nationwide Network*

State/ Union Territory	Medical colleges	ICMR institutions	Other public health research institutes	Non–governmental organizations	State departments (health and nutrition)	Donor agencies	TOTAL
Assam	3	1	1	2	1		8
Manipur	1						1
Meghalya	1				1		2
Nagaland					1		1
Odisha	7	1	3				11
Sikkim					1		1
Tripura	2				1		3
West Bengal	11	1	2				14
Chandigarh	2						2
Delhi	8	2	8	5		2	25
Haryana	1		1		1		3
Himachal Pradesh	2				1		3
Jammu & Kashmir	1				2		3
Punjab	5		3				8
Uttar Pradesh	14		1				15
Uttarakhand			1				1
Goa	1			1			2
Gujarat	10		2		1		13
Maharashtra	19	3	1	1	2		26
Rajasthan	14		1	2			17
Andhra Pradesh	15	1	6	1	2		25
Karnataka	15	1	1		1		18
Kerala	9		1		2		12
Puducherry	1	1					2
Tamil Nadu	8	3	3				14
Bihar	4				2	1	7
Chattisgarh	4						4
Jharkhand	1						1
Madhya Pradesh	10	1	3				14
Grand total	**169**	**15**	**38**	**12**	**19**	**3**	**256**

*States are ordered according to the region/territory.

Crowdsourcing

First round of crowdsourcing

Solicitation of research ideas (RIs) from the Nationwide Network: An online software was designed by INCLEN for submission of RIs by the network. The software had seven separate electronic forms: maternal health (n = 3: mortality, morbidity & stillbirth); newborn health (n = 1); child health (n = 1); and nutrition (n = 2: maternal & child nutrition) themes]. The experts in the nationwide network and RSCs were sent an initial email and then contacted over the phone: (i) to sensitize them about the method of the research priority setting exercise; (ii) to provide them the context and scope of the exercise; and, (iii) the provide them with the purpose of the first round of crowdsourcing. Each participant was provided with an individualized log–in username and password for the dedicated software. The participant could log in to only one of the seven electronic forms as pre–assigned to him/her. After logging–in, s/he was asked to enter personal details (name, area(s) of work, employment status (working/retired), institution, state/union territory, alternative email ID). S/he was then taken through a self–orientation power–point tutorial. The list of AOCs was then displayed on his/her computer screen and the participant was instructed to select any two AOCs to contribute RIs in the four domains of research (description, discovery, delivery and development). The expert was not limited in the number of RIs s/he could submit under each domain. The electronic forms allowed for completion over multiple sessions. An offline version of the form was prepared and shared with participants who had difficulty in accessing the internet. A total of 3497 RIs were obtained across the MNCHN themes from 498 experts (42.3% participation).

Refinement of the research ideas: The RPS project management team at INCLEN along with the RSCs closely examined each RI and rephrased, split, and combined the RIs (as required) keeping the core idea

Table 4. Areas of concern finalized by the National Steering Group

Maternal Health Theme: Maternal Mortality Component:	
1	Hemorrhage
2	Hypertensive disorders of pregnancy
3	Sepsis
4	Obstructed labor
5	Unsafe abortion
6	Anemia and other nutritional problems
7	Medical disorders in pregnancy [eg, chronic hypertension, epilepsy, liver disease, diabetes mellitus, renal disease, thyroid disease, lupus]
8	Malaria in pregnancy
9	Others (Please specify _____)
10	Social determinants of maternal mortality [eg, social isolation, stigmatization, marital disharmony, divorce, household dissolution, domestic violence, loss of community status; caste, religion, teenage pregnancy, cultural practices]
11	Economic [eg, impoverishment and poverty]
12	"Existing" composite public health packages with potential impact on MMR [eg, Janani Shishu Suraksha Karyakram (JSSK)]
13	"Novel & Innovative" composite public health packages with potential impact on MMR [eg, Innovative solutions to promote access to care]
Maternal Health Theme: Maternal Morbidity Component:	
1	Severe acute maternal morbidities (SAMMs) and Near miss events
2	Post partum morbidities and long term disabilities [eg, obstetric fistula, utero–vaginal prolapse, urinary incontinence, dyspaerunia, infertility]
3	Post partum depression and psychosis
4	Strong fear of pregnancy and child birth
5	Social [eg, social isolation, stigmatization, marital disharmony, divorce, household dissolution, domestic violence, loss of community status; caste, religion, teenage pregnancy, cultural practices]
6	Economic [eg, impoverishment and poverty]
7	"Existing" composite public health packages with potential impact on maternal morbidity [eg, syndromic management of RTI & STI; Reproductive, maternal, newborn, child and adolescent health (RMNCH+A)]
8	"Novel & Innovative" composite public health packages with potential impact on maternal morbidity [eg, innovative solutions to promote access to care]
Maternal Health Theme: Stillbirth Component	
1	Maternal cause: Hypertensive disorders of pregnancy
2	Maternal cause: Maternal infections in pregnancy [eg, TORCH group of infections]
3	Maternal cause: Underlying chronic maternal illness [eg, chronic hypertension, epilepsy, liver disease, diabetes mellitus, renal disease, thyroid disease, lupus]
4	Maternal cause: Maternal malnutrition [eg, low maternal BMI, gestational diabetes]
5	Fetal cause: Intra uterine growth restriction
6	Fetal cause: Pre–term birth
7	Fetal cause: Congenital malformations
8	Intra partum cause: Acute hypoxic insult
9	Intra partum cause: Obstetric complications
10	Complications of placenta, cord and membranes
11	Unexplained [By known maternal, placental and fetal conditions]
12	Non-health factors [eg, Indoor air pollution, tobacco smoke]
13	Social determinants of stillbirths [eg, prevailing harmful traditional birth practices, lack of womens' empowerment, poverty, illiteracy]
14	"Existing" composite public health packages with potential to influence stillbirths[eg, Janani Shishu Suraksha Karyakram (JSSK)]
15	"Novel & Innovative" composite public health packages with potential to influence stillbirths[eg, Innovative solutions to promote access to care]
Child Health Theme:	
1	Pneumonia (and ARI)
2	Diarrheal diseases
3	Measles and vaccine preventable diseases
4	Congenital anomalies
5	Malaria
6	Unintentional injuries
7	Acute bacterial sepsis
8	Meningitis/encephalitis
9	Other infections & parasitic diseases
10	Neuro–developmental disorders (NDD) [eg, early developmental delays, autism, speech & language disorders, intellectual disability, epilepsy, CP, neuro–motor impairment, audio–visual impairment]
11	Others (Please specify ____)
12	Social determinants of under 5 mortality rate [eg, immunization refusal, inappropriate feeding practices, poor health seeking behavior.]
13	"Existing" composite public health packages with potential impact on Under 5 Mortality Rate [eg, IMNCI, F-IMNCI, Reproductive, Maternal, Newborn, Child and Adolescent Health (RMNCH+A)]
14	"Novel & Innovative" composite public health packages with potential impact on Under–5 Mortality Rate [eg, Rashtriya Bal Swasthya Karyakram (RBSK) – Child Health Screening and Early Intervention Services]

Table 4. Continued

Newborn Health Theme:	
1	Preterm birth
2	Neonatal sepsis including pneumonia
3	Birth asphyxia & Birth trauma
4	Congenital malformations
5	Others (Please specify _____)
6	Social determinants of NMR [eg, newborn care practices, poverty, poor health seeking behaviour]
7	"Existing" composite public health packages with potential to influence neonatal morbidity and mortality [eg, IMNCI, Home based newborn care, Reproductive, maternal, newborn, child and adolescent health (RMNCH$^+$A)]
8	"Novel & Innovative" composite public health packages with potential to influence neonatal morbidity and mortality [eg, Innovative solutions to promote access to care]
Nutrition Theme: Childhood Nutrition Component	
1	Protein energy malnutrition (PEM)
2	Low birth weight
3	Micro-nutrient deficiencies (iron/folic acid/zinc/iodine/Vitamin A)
4	Childhood overweight and obesity
5	Nutrition deficiency associated congenital malformations
6	Fetal and child nutrition and origin of adult chronic non–communicable diseases [eg, cardiovascular diseases, metabolic syndrome, obesity etc.]
7	Socio–cultural and economic determinants: time constraint with mothers entering into the work force
8	Socio–cultural and economic determinants: care and feeding practices
9	Socio–cultural and economic determinants: competing use of resources for goods and services other than nutrition/food
10	Socio–cultural and economic determinants: globalization & market forces influencing food habits
11	Socio–cultural and economic determinants: status of girl child and women in the community
12	Socio–cultural and economic determinants: use of pesticides & fertilizers
13	Socio–cultural and economic determinants: potable water, hygiene and sanitation
14	Socio–cultural and economic determinants: others (Please specify _____)
15	"Existing" composite public health packages with potential impact on Child nutrition [eg, ICDS, Mid-day Meal Program]
16	"Novel & Innovative" composite public health packages with potential impact on child nutrition [eg, Food fortification program, promotion of kitchen gardens/organic farming, deworming, convergent-innovation coalition to address issues of anemia, under-nutrition, obesity]
Nutrition Theme: Maternal Nutrition Component	
1	Anemia among women of reproductive age group
2	Iodine deficiency disorders among women
3	Vitamin D deficiency among women
4	Maternal overweight & obesity and other non-communicable diseases
5	Socio–cultural and economic determinants: time constraint with mothers entering into the work force
6	Socio–cultural and economic determinants: care and feeding practices
7	Socio–cultural and economic determinants: competing use of resources for goods and services other than nutrition/food
8	Socio–cultural and economic determinants: globalization & market forces influencing food habits
9	Socio–cultural and economic determinants: women's status in the community, family structures and norms
10	Socio–cultural and economic determinants: others (Please specify _____)
11	"Existing" composite public health packages with potential impact on maternal nutrition
12	"Novel & Innovative" composite public health packages with potential impact on maternal nutrition

intact and without discarding any RI. The original RI list was maintained as a separate file for ready reference at any time. The process was intuitive, consultative and iterative (completed through brainstorming by teams over several sittings). As far as possible, the RIs were refined in a way that described the population, intervention, control, and outcome (PICO). This process led to a compendium of 4003 RIs from the original 3497 RIs. (**Table 5**).

Development of research options (ROs): The 4003 RIs were consolidated onto 373 ROs. These were crystallized through iterative refinement to avoid duplication and redundancy. Each RO represented a portfolio of inter–related RIs that addressed a central research concept. Thus, the ROs addressed multiple AOCs and several of these pertained to cross–cutting issues across domains, components and themes. The ROs were finally categorized into four themes (maternal health: 122, newborn health: 56, child health: 101, nutrition: 94) (**Table 6**).

Second round of crowdsourcing

Finalization of criteria for scoring: Previously published CHNRI exercises were reviewed extensively to retrieve scoring criteria used in past exercises. Two rounds of consultation were held with RSC members, international CHNRI experts, and experts from the World Health Organization who had been close-

Table 5. Research ideas obtained through the first round of crowd–sourcing and subsequent refinement

Theme	Component	Total number of areas of concern	Number of research ideas (received)	Number of research ideas (after refinement)
Maternal health	Mortality	13	436	523
	Stillbirths	15	418	542
	Morbidity	8	353	243
	Lateral submissions*		11	–
	Subtotal		**1218**	**1308**
Newborn health	–	8	**641**	**626**
Child health	–	12	**596**	**648**
Nutrition	Maternal nutrition	12	450	590
	Childhood nutrition	16	590	831
	Lateral submissions*		2	–
	Subtotal		**1042**	**1421**
	Total		**3497**	**4003**

*Research ideas received from the National Steering Group as and when through hand–written submissions.

ly associated with previous CHNRI exercises. Five succinctly worded criteria (answerability, relevance, equity, innovation and out–of–the–box thinking, and investment on research) were finalized. These criteria were believed to be consistently applicable across domains, themes and ROs (**Box 2**). The context and scope of the present exercise, nature of the ROs and the large number of scorers from various disciplines across India that were to score the research options were the key considerations while deciding on the scoring criteria to be used. The scorers were expected to evaluate the ROs against the criteria by choosing one of the following responses: *'Yes'* if the research option favorably met the criterion query, *'No'* if it did not, and *'Not my expertise'* if the scorer felt that s/he was not sufficiently informed to adjudge the research option against the particular criterion. While other CHNRI exercises employed sub–questions under each criterion, we chose to forego sub–questions as we were advised that sub–questions usually had high agreement [12] and also because our exercise had a large number of ROs to be scored and we were

Table 6. Distribution of the research options in the domains of research

Domain of research	Frequency (%) of research options in themes			
	Maternal health	Newborn health	Child health	Nutrition
Description	42 (34.4)	15 (26.8)	39 (38.6)	35 (37.2)
Delivery	57 (46.7)	24 (42.9)	37 (36.6)	42 (44.7)
Development	44 (36.1)	21 (37.5)	37 (36.6)	27 (28.7)
Discovery	8 (6.6)	4 (7.1)	4 (4.0)	2 (2.1)
Single domain	29 (23.8)	8 (14.3)	16 (15.8)	12 (12.8)
>1 domain	93 (76.2)	48 (85.7)	85 (84.2)	82 (87.2)
Total (N = 373)	**122 (100.0)**	**56 (100.0)**	**101 (100.0)**	**94 (100.0)**

Box 2. Scoring criteria and their definitions

1. **Answerability.** Can the research be done through ethical, transparent, well–designed, "do–able" studies with the existing local and national capacities and or by strengthening the existing capacities through regional or global collaboration?
2. **Relevance.** Is it likely that the research would address a high burden condition and critical gap in knowledge?
3. **Innovation and out–of–box thinking to resolve complex, and refractory challenges.** Does the new research have the potential for transformative change in the health system/ health care?
4. **Equity.** Is it likely that the research product will address the differences in health and nutrition that are systematically associated with social, cultural and economic hierarchies, ethnicity, gender, environment and geographic disadvantages, thereby reducing inequities?
5. **Investment on research.** Is it likely that the potential impact and benefits of the new knowledge on health/ nutrition will outweigh the consideration of investments on research?

aiming to maximize retention of participants by minimizing scorer fatigue, especially in order to preserve the validity of our planned regional analyses.

Scoring of the research options by the Nationwide Network: The scoring exercise was done using a user–friendly online interface *(www.surveymonkey.com)* that allowed for having individualized scorer accounts that could be accessed through an invitation email from the INCLEN RPS project management team. The software could readily archive access details (email and IP addresses) and responses selected by the scorer. Once the scorer logged in, s/he underwent a comprehensive orientation of the context and method of the exercise, and the scoring criteria and process. Thereafter, ROs appeared in a random sequence, one at a time, on the scorer's computer/smart phone screen. The scorer was requested to score all the ROs for the assigned theme. As the number of ROs to be scored was high and could have led to high scorer burden and attrition, each scorer was randomly allocated a combination of two of the five criteria for scoring. Five such criteria combinations (survey questionnaires) had been prepared for scoring: (i) Answerability and Innovation; (ii) Answerability and Equity; (iii) Relevance and Innovation; (iv) Relevance and Investment on Research; and (v) Equity and Investment on Research. The nationwide network was stratified at two levels: first, according to their participation status in the first round of crowd sourcing ('participated', 'could not participate', or 'newly invited' experts); and, second, according to their region. Subsequently, the experts within each region were equally distributed across the five survey questionnaires within the theme through consecutive allocation (the expert with serial number 1 got Survey Questionnaire 1; the next in line got Survey Questionnaire 2 and so on; the questionnaire allocation cycle was restarted with every 6th expert).

It was mandatory for the scorer to evaluate the RO on the screen against both of the assigned criteria before moving on to the next RO (ie, skip logic was disabled). However, the scorer could review and edit his previous responses once s/he had moved forward. Completion over multiple sessions was allowed to avoid effects of scorer fatigue and overcome time constraints. The RPS project management team at INCLEN remained vigorously engaged with the nationwide network through email and telephone for immediate troubleshooting and timely reminders, and used continuous real–time data monitoring to check progress. Scorers who requested hard copies of the questionnaires instead of the online process were provided with the same for recording the responses. In the second round of crowdsourcing, 893 scorers participated (58.1% participation rate) (**Table 7**).

Assignment of relative criteria weights by the LRG

The LRG members were given an in–depth explanation of the CHNRI exercise. They were then requested to assign relative weights to the scoring criteria by distributing a hypothetical amount of Indian Rupees (INR) 100 across the five criteria, giving the maximum amount to the criteria they felt to be the most important and the minimum to the least important. The relative weight for each criterion was computed by calculating the arithmetic mean of the average amount received by the respective criterion in each LR6 constituency (**Table 8**). Of 84 members approached for the LRG, 79 participated (94.0% participation). The LRG ascribed maximum relative weight to Relevance (0.254), followed by Innovation and Out–of–Box Thinking (0.199), Equity (0.193), Answerability (0.192), and Investment on Research (0.161).

Data management and analysis

The *"Yes"* and *"No"* responses were scored as "1" and "0" respectively. The *"Not my expertise"* responses were excluded from the calculations. Relative ranking and Research Priority Scores (RPS) were calculated as follows [13]:

Table 7. Distribution of experts who participated in the 2nd round of crowd–sourcing (the Scoring Exercise)

Region	Maternal health			Newborn health			Child health			Nutrition			Overall		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
EAG States and North Eastern States	39	48	87	39	23	62	55	14	69	42	28	70	175	113	288
Northern States and UTs (including West Bengal)	25	44	69	57	15	72	52	16	68	31	29	60	165	104	269
Southern and Western States and UTs	39	55	94	37	27	64	69	27	96	32	50	82	177	159	336
Total	**103**	**147**	**250**	**133**	**65**	**198**	**176**	**57**	**233**	**105**	**107**	**212**	**517**	**376**	**893**

EAG – Empowered Action Group, UT – Union Territories

Average scores received against each of the five criteria were calculated for each RO.

1. The criteria weights (as assigned by the LRG) were applied to the mean score received by each criterion.
2. Research Priority Scores (RPS) were calculated by adding together each criterion's weighted scores for each RO.

The ROs were arranged in descending order of their RPS to get national and regional rankings. Work location of the scorer as entered by him/ her at the time of the scoring determined the regional ranking.

Average Expert Agreement (AEA) [14] was also calculated for each RO. The AEA is a proportion of scorers who scored the most common score for a particular RO divided by the total number of scorers who scored that RO.

The second meeting of the NSG reviewed the ranked list of national and regional research priorities. The group further suggested to identify ROs relevant to three more themes: (i) adolescence; (ii) issues cutting across four MNCHN themes for greater impact on health and health systems; and, (iii) areas requiring biotechnology methods from the compendium of 373 ROs, and generate ranked lists according to their RPS for each of these.

The results from all exercises are reported in–depth separately in manuscripts prepared for submission to the Journal of Global Health. The overall discussions by the National Steering Group on the results and way forward for the exercise has been accepted for publication in the *Indian Journal of Medical Research*.

DISCUSSION

The COHRED Working Group on Priority Setting highlighted that engagement of a wide spectrum of stakeholders is essential to identify priorities that reflect research needs, available technical and financial capacity, and societal values and ethics [15]. Stakeholder engagement, and data and capacity constraints frequently impeded the process for setting priorities, more so in the LMICs [16]. The current exercise, through systematic inclusion of diverse range of national stakeholders in a LMIC setting, identified priorities for maternal, neonatal and child health and nutrition at national and sub–national (regional) levels. The exercise leveraged the inherent flexibility of the systematic CHNRI method and built further methodological robustness. CHNRI exercises hitherto had taken a conservative approach in considering active contribution to research/policy as a selection pre–requisite for scorers. In contrast, we expanded the stakeholder base to include diverse range of doers and users (techno–managerial) of research in the field of MNCHN. This helped in including a variety of viewpoints in the scoring process and possibly, led to prioritization of ROs that was important to both.

Having Indian nationals as the exclusive contributors and scorers to this exercise makes it unique from previous exercises. In this way, this CHNRI exercise is truly a representation of, and driven by, India's health and nutrition community. Moreover, the exercise is the first to conduct subnational–level analysis which, in a country as large and diverse as India, is imperative to truly explore research priorities and enable the country to tailor interventions regionally. With effective use of technology and building on INCLEN's network for multi–centric studies, 498 experts from across India contributed research ideas and 893 experts were involved in the scoring process. About 75 (60–96) experts were involved per region per theme to score the ROs. The large number of scorers ("sample size") should have led to saturation and stable estimate of priority ranks at national and sub–national (regional) levels [8]. The improved response

Table 8. Relative weights assigned to the scoring criteria by the Larger Reference Group

LRG categories	Answerability	Relevance	Equity	Innovation	Investment on research
Policy decision makers, politicians (N = 18)	0.197	0.229	0.209	0.203	0.162
Eminent researchers (N = 17)	0.212	0.245	0.169	0.197	0.177
MNCHN program managers from central and state governments (N = 24)	0.186	0.254	0.201	0.198	0.162
Funding agencies (N = 20)	0.173	0.288	0.195	0.200	0.145
Overall (N = 79)	**0.192**	**0.254**	**0.193**	**0.199**	**0.161**

LRG – Larger Reference Group, MNCHN – Maternal, Newborn, Child Health and Nutrition

rates between first and second rounds of crowdsourcing should have reduced bias [17]. Gender distribution of scorers is a reflection of skewed gender participation in program management, research and academia for the themes considered in this exercise. The scorer profiles have been discussed in details in the respective thematic papers prepared for submission to JoGH.

To minimize scorer fatigue, we asked the participants to score against predefined pairs of criteria allocated randomly to them instead of all five criteria. The AEA for each evaluated research option represents the proportion of scorers that gave the most frequent (modal) response [14]. For the top 10 ROs at national level across the themes, the AEA for both individual and aggregate of the five criteria was fairly high (maternal health: 0.887–0.929; newborn health: 0.871–0.902; child health: 0.899–0.923; nutrition: 0.869–0.923) indicating consistency among the scorers. This also indicates minimal bias due to partial criteria scoring adopted in the current exercise and appears to be a pragmatic approach for better participant compliance without affecting the validity of the priority setting scoring. There were four distinct constituencies among the LRG; the LRG is to be viewed as a strength since different constituencies are likely to have differences in their collective perspective about research priorities [18]. It was interesting to observe that "Relevance" was accorded the highest weight by all the LRG sub–groups highlighting that priorities should be suited to the context.

In view of the disease burden and significance of the health systems in the implementation and delivery of services, the NSG suggested developing ranked priority lists for adolescent health, cross cutting themes and biotechnology related ROs from the 373 ROs spread across different themes. These lists will, at best, be an indicative priority list because the ROs were picked up from different thematic groups, scored by dissimilar set of experts with differences in their professional expertise. Although the overall AEA was high across themes, the validity of RO scores to determine their relative ranking shall remain unknown for these additional lists.

The exercise was the largest to–date use of the CHNRI methodology in terms of research ideas collected, processed and scored, and the number of participants and spectrum of stakeholder constituencies engaged. It expanded on the CHNRI methodology and thus, contributes to further evolution of the CHNRI method as a robust, inclusive, participatory, transparent and objective technique for identification of research priorities. It has been opined that prioritization processes will have an impact only if funders have a buy–in. It is also anticipated that there is an imminent challenge to develop tools to detect and evaluate the impact of CHNRI exercises on funder decision making and priorities [19]. A recent article in Lancet affixes with the research funders and research regulators, the primary responsibility of addressing the sources of avoidable waste once research priorities are set [20]. We hope that ICMR–INCLEN collaborative effort helps in rational distribution of health and nutrition research budget by the Government of India and donor agencies funding research in India and in similar LMIC contexts, and also inform any mid–course correction of currently funded research portfolio as needed. Sub–national (regional) prioritization should further help in matching the exercise's findings to other LMIC contexts. This exercise can serve as a guidance for other LMICs, especially those with diversity among their populations, in setting research priorities nationally.

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Authorship contributions: NKA was the PI and provided overall leadership to the entire exercise by chairing the NSG meetings. He was responsible for the conception and design of the exercise, acquisition and interpretation of data, revising the manuscript critically and for the final approval of the version submitted. All communications with the network and request for participation in the exercise were made on his behalf. AM, HSG, MM and MKD were part of the INCLEN RPS project management team. AM was responsible for review of literature, execution of the project, identification of participants, communication with the network, management and analysis of the data and for drafting the manuscript. HSG and MM were responsible for management of the network, data archiving and retrieval, supporting AM in data analysis and in preparing the draft manuscript. KW and IR provided critical technical and strategic inputs for the design and execution of the exercise. All authors were responsible for providing technical guidance to the exercise at different points of the project lifecycle, and in critically reviewing and editing the manuscript for intellectual content and in approving the final version for submission.

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REFERENCES

1 A New Approach in Systematic Priority Setting in Child Health Research Investment. 2006. Bangladesh: Child Health and Nutrition Research Initiative (CHNRI) 2006. Available: http://www.chnri.org/secured/uploads/publications/files/0535210001249198837-604_file_PRIORITY_SETTING_.pdf. Accessed: 20 August 2016.

2 Rudan I, Gibson J, Kapiriri L, Lansang MA, Hyder AA, Lawn J, et al. Setting priorities in global child health research investments: assessment of principles and practice. Croat Med J. 2007;48:595-604. Medline:17948946

3 Fontaine O, Martines J, Bahl R, Briend A, Muhe L, El Arifeen S, et al. Setting health research priorities to address Millennium Development Goal 4 and Child Mortality at the Global Level. 2006. Available: http://www.chnri.org/secured/uploads/publications/files/0535210001249198837-604_file_PRIORITY_SETTING_pdf. Accessed: 20 August 2016.

4 Yoshida S. Approaches, tools and methods used for setting priorities in health research in the 21st century. J Glob Health. 2016;6:010507. Medline:26401271 doi:10.7189/jogh.06.010302

5 The 10/90 Report on Health Research 1999. Global Forum for Health Research. Geneva Switzerland. 1999. Available: http://announcementsfiles.cohred.org/gfhr_pub/assoc/s14791e/s14791e.pdf. Accessed: 15 January 2017.

6 Ghaffar A. Setting research priorities by applying the combined approach matrix. Indian J Med Res. 2009;129:368-75. Medline:19535830

7 Rudan I, Yoshida S, Chan KY, Sridhar D, Wazny K, Nair H, et al. Setting health research priorities using the CHNRI method: VII. A review of the first 50 applications of the CHNRI method. J Glob Health. 2017;7:011004.

8 Yoshida S, Rudan I, Cousens S. Setting health research priorities using the CHNRI method: VI. Quantitative properties of human collective opinion. J Glob Health. 2016;6:010503. Medline:27350874 doi:10.7189/jogh.06.010503

9 Rudan I, Chopra M, Kapiriri L, Gibson J, Lansang MA, Carneiro I, et al. Setting priorities in global child health research investments: universal challenges and conceptual framework. Croat Med J. 2008;49:307-17. Medline:18581609 doi:10.3325/cmj.2008.3.307

10 Wazny K. 'Crowdsourcing' ten years in: a review. J Glob Health. 2017;7:forthcoming.

11 Tomlinson M, Chopra M, Sanders D, Bradshaw D, Hendricks M, Greenfield D, et al. Setting priorities in child health research investments for South Africa. Available: http://www.chnri.org/secured/uploads/publications/files/0535210001249198837-604_file_PRIORITY_SETTING_.pdf. Accessed: 20 August 2016.

12 Wazny, Kerri (University of Edinburgh, Scotland, UK). In conversation with: Rudan, Igor (University of Edinburgh, Scotland, UK). 12 May 2015.

13 Rudan I, Gibson JL, Ameratunga S, El Arifeen S, Bhutta ZA, Black M, et al. Setting priorities in global child health research investments: guidelines for implementation of the CHNRI Method. Croat Med J. 2008;49:720-33. Medline:19090596 doi:10.3325/cmj.2008.49.720

14 Bahl R, Martines J, Ali N, Bhan MK, Carlo W, Chan KY, et al. Research priorities to reduce global mortality from newborn infections by 2015. Pediatr Infect Dis J. 2009;28(1 Suppl):S43-8. Medline:19106763 doi:10.1097/INF.0b013e31819588d7

REFERENCES

15 The Working Group on Priority Setting. Priority setting for health research: lessons from developing countries. Health Policy Plan. 2000;15:130-6. Medline:10837035 doi:10.1093/heapol/15.2.130

16 McGregor S, Henderson KJ, Kaldor JM. How are health research priorities set in low and middle income countries? A systematic review of published reports. PLoS One. 2014;9:e108787. Medline:25275315 doi:10.1371/journal.pone.0108787

17 Yoshida S, Cousens S, Wazny K, Chan KY. Setting health research priorities using the CHNRI method: II. Involving researchers. J Glob Health. 2016;6:010302. Medline:27350870 doi:10.7189/jogh.06.010302

18 Rudan I. The complex challenge of setting priorities in health research investments. Indian J Med Res. 2009;129:351-3. Medline:19535827

19 Rudan I, Yoshida S, Chan KY, Cousens S, Sridhar D, Bahl R, et al. Setting health research priorities using the CHNRI method: I. Involving funders. J Glob Health. 2016;6:010301. Medline:26401269

20 Chalmers I, Bracken MB, Djulbegovic B, Garattini S, Grant J, Gülmezoglu AM, et al. How to increase value and reduce waste when research priorities are set. Lancet. 2014;383:156-65. Medline:24411644 doi:10.1016/S0140-6736(13)62229-1

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PAPERS

Setting health research priorities using the CHNRI method: VII. A review of the first 50 applications of the CHNRI method

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Background Several recent reviews of the methods used to set research priorities have identified the CHNRI method (acronym derived from the "Child Health and Nutrition Research Initiative") as an approach that clearly became popular and widely used over the past decade. In this paper we review the first 50 examples of application of the CHNRI method, published between 2007 and 2016, and summarize the most important messages that emerged from those experiences.

Methods We conducted a literature review to identify the first 50 examples of application of the CHNRI method in chronological order. We searched Google Scholar, PubMed and so–called grey literature.

Results Initially, between 2007 and 2011, the CHNRI method was mainly used for setting research priorities to address global child health issues, although the first cases of application outside this field (eg, mental health, disabilities and zoonoses) were also recorded. Since 2012 the CHNRI method was used more widely, expanding into the topics such as adolescent health, dementia, national health policy and education. The majority of the exercises were focused on issues that were only relevant to low– and middle–income countries, and national–level applications are on the rise. The first CHNRI–based articles adhered to the five recommended priority–setting criteria, but by 2016 more than two–thirds of all conducted exercises departed from recommendations, modifying the CHNRI method to suit each particular exercise. This was done not only by changing the number of criteria used, but also by introducing some entirely new criteria (eg, "low cost", "sustainability", "acceptability", "feasibility", "relevance" and others).

Conclusions The popularity of the CHNRI method in setting health research priorities can be attributed to several key conceptual advances that have addressed common concerns. The method is systematic in nature, offering an acceptable framework for handling many research questions. It is also transparent and replicable, because it clearly defines the context and priority–setting criteria. It is democratic, as it relies on "crowd–sourcing". It is inclusive, fostering "ownership" of the results by ensuring that various groups invest in the process. It is very flexible and adjustable to many different contexts and needs. Finally, it is simple and relatively inexpensive to conduct, which we believe is one of the main reasons for its uptake by many groups globally, particularly those in low– and middle–income countries.

The global health research system is an extremely complex network of many diverse actors. It includes large funding agencies, national, regional and international organizations, pharmaceutical and biotech industry and philanthropy–oriented foundations, all of which invest in health research with different aims [1]. The research itself thrives in well–managed and meritocratic universities and research institutes, but also in the private sector. It is assisted by life–long education opportunities for scientists, the supporting industries that develop new research tools, and even by "citizen scientists" – a new breed of researchers [2]. Scrutiny over the health research process is in the hands of many individual research policy makers, ethics committees, peer reviewers of grant proposals and research articles. The dissemination and translation of the results is in the hands of governments, professional bodies, publishers and journal editors, conference organizers, guidelines developers, but also science–focused journalists and media, patent lawyers and many other stakeholders [1]. All of these individuals, groups and organizations act together continuously to conduct, facilitate, support and promote health research and utilize its results. Their collective aim is to generate new knowledge on human health and disease and improve health outcomes for our planet's population [2].

Given that a spectrum of possible ideas for health research is extremely broad and diverse, a need to prioritize between competing research questions arises at different levels – globally, regionally, nationally and locally. Therefore, the process for setting health research priorities is a genuine need and it is being exercised in various forms, but the effectiveness of different approaches is very difficult to evaluate. A recent review described and compared priority–setting tools used in health research prioritization in the 21st century [3]. There seems to be a general consensus among researchers that a flexible, systematic, transparent and replicable process for setting health research priorities would be a desirable tool that could improve the legitimacy of priority–setting exercises at all levels [3,4].

The CHNRI method for setting health research priorities

The Child Health and Nutrition Research Initiative (CHNRI) started as an initiative of the Global Forum for Health Research in Geneva, Switzerland [4]. One of its main aims was to develop a tool that could assist decision–making and priority setting in health research investments to improve child health and nutrition. Their method also sought to achieve an acceptable balance between fundamental research, translational research and implementation research in order to maximize the potential of health research in reducing both disease burden and the inequities among the world's children [5].

The CHNRI method was developed between 2005 and 2007 through 12 consecutive meetings of a trans–disciplinary panel of 15 experts, supported with funding from the World Bank. The experts worked together to address a number of key challenges related to the multi–dimensional problem of setting priorities in health research investments [5–7]. The method aimed to carefully define the *context* for health research priority setting. The components of the context were: (i) the health issue on which the research is focused; (ii) the affected population that would benefit from the investments in health research; (iii) the timeframe within which the impact of supported research was expected (eg, short, medium or long term); (iv) the style of investment (eg, risk aversive or risk–seeking); and (v) the expected returns from investment (eg, burden reduction, patents, or various forms of public recognition) [6–8].

The method also introduced a systematic approach to listing many competing research questions. It identified four fundamental instruments of health research – "*the four D's*" – research to achieve (i) *description* (through epidemiological research), (ii) *discovery* (through basic, ie, fundamental research), (iii) *development* (through translational research) and (iv) *delivery* (through health policy and systems research, which includes delivery, operations and implementation research). Moreover, it addressed the difference in depth and breadth of suggested research questions by categorizing them in broad *research avenues*, more focused *research options* (which correspond to a 5–year research program), and very specific *research ideas/questions* (which correspond to a typical research article). Finally, the method introduced a transparent *set of criteria* that could discriminate between many competing research options. CHNRI's "standard" set of criteria followed a simple conceptual framework that demonstrated how the process of health research generates new knowledge. The five suggested criteria were (i) answerability, (ii) effectiveness, (iii) deliverability, (iv) the potential for a substantial reduction of disease burden and (v) the impact on equity [6–8].

The typical CHNRI process involves a small management team that reaches out to a large number of researchers (but also policy–makers and program managers, depending on focus of the exercise) who contribute hundreds of research ideas [9,10]. Once a list of a manageable number of research ideas/questions (usually up to 200) is consolidated by removing overlapping ideas and integrating related ideas, a num-

ber of researchers (from 20 to up to several hundreds, depending on the context) are invited to score all proposed research questions against each priority–setting criterion [7,10]. Their input measures "collective optimism" on a scale 0–100. In the final step, external stakeholders are invited to set different thresholds and weights for each of the priority–setting criteria, giving some criteria greater importance over the others, so that the overall score also includes the value system of a wider community [2]. The final output of the CHNRI process is a list that ranks up to 200 research ideas/questions by their scores against several transparent priority–setting criteria [7]. This serves to reveal strengths and weaknesses of all submitted research questions to the research community, judged by a subset of this community using several key criteria for prioritization [8].

The examples of implementation

We conducted a review of the literature to identify the first 50 examples of the application of the CHNRI method in chronological order, to study the evolution of the uptake of the method. There are presently more than 50 examples of application, with further CHNRI exercises being conducted or planned, but not all of them have reached their final stage of peer–reviewed publication. Therefore, to acknowledge a milestone in method's implementation, we decided to focus on the first 50 publications that have been reviewed and published. We searched Google Scholar, PubMed and so–called "grey literature" (usually defined as papers produced by organizations outside of the traditional publishing and distribution channels) using the search term "CHNRI" or "Child Health and Nutrition Research Initiative". The first 50 CHNRI priority–setting exercises, published between 2007 and 2016 (the full list with details of each study is available in Table S1 in **Online Supplementary Document**), reached out to nearly 5000 researchers, policy makers and program officers, seeking their participation in the generation of research ideas/questions and the scoring of those questions according to the proposed criteria. The initial response rate across all exercises was above 60%, with more than 3000 experts submitting research ideas. They submitted about 10 000 ideas (more than 3 per expert). The redundancy rate in submitted questions was slightly above 50%, indicating a relatively high rate of duplicate ideas. Eventually, 4282 ideas were scored (an average of 86 per exercise) by 2403 participating scorers (an average of 48 per exercise). Most of the papers were published in journals including *PLoS Medicine* (20%), *BMC Public Health* (14%) and *Lancet* (12%). Among the six exercises published in the *The Lancet* journal, three were published as stand–alone exercises and three were a part of policy recommendation papers or "calls for action" within the Lancet series (see Table S1 in **Online Supplementary Document**).

Table 1. The main characteristics of the design of the 50 research priority–setting exercises based on the CHNRI method published to date related to the context of the exercise

Health issue addressed through research	Number	Proportion (%)
Child mortality (all–cause or individual causes)	26	52
Child morbidity and suboptimal development	2	4
Sexual health	4	8
Major infectious diseases (eg, tuberculosis, zoonoses)	3	6
All–cause disability	1	2
Mental health	8	16
Dementia	1	2
Health and education system related research	2	4
All–cause morbidity and mortality	3	6
Context of the CHNRI exercise:		
Global	16	32
Low– and middle–income countries	25	50
National	7	14
Sub–national	1	2
Crisis setting	1	2
Time frame until the expected impact of research:		
Less than 10 years	10	20
10 years	37	74
More than 10 years	3	6
Population that would benefit from research:		
Stillbirths or neonates (<1 month)	7	14
Children aged 1 month – 5 years	17	34
Children older than 5 years	4	8
Adolescents and young adults	8	16
Population aged 60 and above	1	2
People with HIV / with mental health illnesses / disability	4	8
All age groups	9	18
Involvement of external stakeholders:*		
Yes	13	26
No	37	74

*Population groups other than funders of research and their representatives, researchers and/or technical experts involved in the exercise.

Clarity over the context of prioritization and the criteria used for prioritization is one of the key conceptual advances of the CHNRI method. Given the history of the development of the CHNRI method and its initial focus on the reduction of child mortality, it is not surprising that the majority of the exercises have addressed child mortality (either all–cause or specific causes) (52%) (**Table 1**). The use of the CHNRI method was then extended to questions related to childhood morbidity and improved development (4%). In a logical progression of the method's application to address the key global health issues, it was applied to questions of maternal, perinatal and sexual health (8%), followed by several major infectious diseases, such as tuberculosis and zoonoses (6%). Then, the method started to find its application in areas outside of its initial focus – such as mental health (16%), all–

cause mortality, morbidity and disability in adults (8%) and dementia (2%). Most exercises were focused on low– and middle–income countries (50%). Further 32% of CHNRI exercises were global in scope, but there were also 14% of exercises conducted at the national level, and 2% at a sub–national level (**Table 1**). This shows that application of the CHNRI method is beginning to expand to health issues beyond the initial focus on child health, and to national and sub–national levels, where there is also a lot of need for prioritization of health research. This is further reflected in 56% of exercises being focused on children (including newborns), 16% on adolescent and young adults, and 28% on adults or all age groups (**Table 1**).

In terms of the adopted time frame until the expected impact of research, the large majority of the exercises (74%) used a "standard" time frame of 10 years, originally suggested in the guidelines for implementation of the CHNRI method. A sizable minority of the exercises deviated from the recommended timeframe to suit the contexts to which the exercises were conducted; 20% of the exercises had shorter timeframes, while 6% had longer time frames (**Table 1**). The evolution of the originally proposed CHNRI method through its implementations is particularly apparent when the criteria used for prioritization are analyzed across the 50 exercises. The originally proposed 5 criteria were used only in one–third of the exercises, while they were modified in two–thirds. Modification included changes in the number of criteria used, and the changes in the criteria themselves. Although 56% of all exercises used 5 criteria, as originally suggested, 12% reduced their number to only four or three, while 32% expanded the number of criteria applied – up to 13 in one exercise. Interestingly, although the five "standard" criteria were used most frequently, as expected (from 86% for equity to 70% for effectiveness), it is clear that the groups conducting the CHNRI processes felt a need to replace them and/or introduce further criteria in their exercises, or even reduce their number. The most frequently added criteria were feasibility (in 22% of all exercises), acceptability (22%), low cost (22%), sustainability (22%) and relevance (12%). This shows the flexibility of the CHNRI process in allowing the use of different priority–setting criteria. Adjustments of the process to the needs of each specific exercise should be strongly encouraged (**Table 2**).

Table 2. The main characteristics of the design of the 50 research priority–setting exercises based on the CHNRI method published to date related to the criteria used for prioritization

	Number	Proportion (%)
Number of priority–setting criteria used:*		
Three	2	4
Four	4	8
Five	28	56
Six	5	10
Seven or more	11	22
Priority–setting criteria most frequently used:		
Equity	43	86
Answerability	42	84
Impact on disease/disability burden	39	78
Deliverability	36	72
Effectiveness	35	70
Low cost	11	22
Sustainability	11	22
Acceptability	11	22
Feasibility	11	22
Relevance	6	12
Applicability	4	8
Ethical	3	6
Attractiveness and originality	3	6
Fundability	2	4
Fills a key gap / potential for breakthrough	2	4
Clarity	2	4
Potential for translation	2	4
Local ownership	2	4
Usefulness (eg, for guiding policies and programmes)	2	4
Sensitivity/immediacy/long–term impact/obstacles to scale–up/need/quality/operationalizability	1	2

*Less than a third (n = 16) of all exercises used the original, "standard" set of the CHNRI criteria; more than two–thirds (n = 34) of the exercises modified the set to adjust it to the need of a particular exercise.

The main messages from the conducted exercises

As a whole, the 50 CHNRI exercises generated several very broad messages relevant for health research policy. First, if the health issue that was the focus of the prioritization exercise was not well understood in terms of its burden in the population, or the risk factors that contributed to the issue, or the interventions that could be effective in controlling and mitigating the issue, then descriptive (epidemiological) research was identified as the leading research priority as a rule. This showed that generating the knowledge on the burden of the health issue and its "architecture" (in terms of contributing factors and effective interventions) was usually identified as the leading research priority, wherever such knowledge was unavailable.

Given that most contemporary health issues have a reasonably well–defined burden in the population and risk factors, and that effective interventions to reduce or control the burden do exist but are not being implemented, it is not surprising that research on delivery, including health policy and systems, along with operations and/or implementation research frequently dominated the exercise, particularly in low– and middle–income countries [11]. An additional important factor that explains why delivery research was frequently identified as a research priority is the relatively short time frame within which the impact was expected in most exercises (eg, 10 years) and greater urgency to reduce child mortality among the un-

der–privileged populations of the world. Had the health issue been less devastating (eg, mild chronic diseases), and the specified time frame longer (eg, 20–30 years), it is very likely that research priorities would have shifted toward development research and discovery research [11].

Still, there were many examples where "*development*" (translational) research questions and "*discovery*" (basic, ie, fundamental) research questions made it close to the top of the list of priorities. Translational research questions were scored highly wherever there were pre–existing and effective interventions which required some clearly defined and straight–forward modification so as to enable their scale–up in low– and middle–income settings (eg, vaccines stable at high external temperatures). Research questions that required discovery (fundamental) research were prioritised in the exercises where the time frame was longer than 10 years and where hardly any effective interventions were available to reduce or control the health issue (eg, the effect of exercise on dementia and Alzheimer disease [12]). This begs the questions: 1) what time horizon(s) grant agencies adopt and how these differ across agencies; and 2) whether this is explicit or implicit and how this is decided – as the time frame of research questions clearly influences research prioritisation.

The key advantages of the CHNRI method

We believe that the popularity of the CHNRI method in setting health research priorities can be attributed to several key advances that it proposed. These advances addressed common concerns that persisted following the previous exercises. First, the CHNRI method is *systematic,* because it offered an acceptable framework for handling an endless spectrum of research questions, which provided equal opportunity to questions from different categories of health research.

Second, it is also *transparent,* because it clearly defines the context and priority–setting criteria and provides a replicable approach. All stages of the process and all input can be easily documented and stored in the form of a numerical data set upon which the priorities can be set.

Third, the CHNRI process is *democratic*. It relies on a "crowd–sourcing" approach to both submission of research questions and scoring of the proposed questions. In this way, no single participant in the exercise can have a decisive (or undue) influence on the final ranks. The scores reflect the *collective opinion* of the sample of researchers and other experts from the research community, with each individual input contributing only a minor fraction to the overall scores. The central idea of the crowd–sourcing principle is that a diverse collection of independently–deciding individuals will be likely to make certain types of decisions and predictions better than any experts in the great majority of cases [13].

Fourth, the CHNRI process is *inclusive*, fostering "ownership" of the results by ensuring the various groups invest in the process. This means that an appropriate role is given to donors, researchers and other stakeholders, all of whom can have a substantial influence on the final list of priorities: donors, through defining the context and criteria [9]; researchers, through providing research questions and scoring them [10]; and other stakeholders, through being able to assign more importance (weight) to some criteria over the others [2].

Fifth, the CHNRI process is extremely *flexible* and adjustable to many different contexts and needs. It is very easy to modify it by adjusting the components of the context and adding additional useful priority–setting criteria, as demonstrated through these first 50 applications. Sixth, the CHNRI process is extremely *simple*, which we believe is one of the main reasons for its uptake by many groups globally that haven't been trained in the application of the method. It is enough to study any previously conducted exercise to be able to easily organize and conduct it within any other setting. Although quantitative in its outcomes, the CHNRI method is based on a simple, qualitative input (Yes/No), avoiding any complicated mathematical or statistical computation to obtain the results. Intuitive scores that range between 0–100% and measure collective optimism of a group of experts toward each component of each research question are understandable to users, replicable, amenable to agreement statistics, post–exercise validation and evaluation [14,15]. Seventh, the CHNRI method is reasonably *inexpensive* to conduct. Finally, the results of the CHNRI method are relatively easy to disseminate to the global audience, as the process for priority–setting is structured, objective, replicable and transparent.

The main points of concern to address in the future

There are several concerns that were expressed in relation to the CHNRI process and they will need careful addressing. First, there is a risk that the spectrum of research ideas submitted and evaluated in the

CHNRI process is not comprehensive and that it is missing some particularly promising research questions. Second, the response rate of the invited researchers, policy–makers and program leaders typically ranges between 30–70%, which means that a significant response bias could be introduced at this step [9]. It should be explored whether those who responded to the invitation to participate in the CHNRI exercises differed significantly from those who declined [9]. Third, statistical simulations using data sets from the conducted CHNRI exercises established the minimum number of expert scorers required per exercise to achieve "stable" scores and ranks, above which further addition of experts is unlikely to change the results, and these thresholds should be respected [14,15]. Fourth, a series of experiments on quantitative properties of human collective knowledge and opinion was designed and conducted to demonstrate that collective predictions indeed out–perform individual predictions in the vast majority of cases, but there were still some individuals who managed to out–perform the group's prediction [14,15].

Another risk of bias comes from the process of compiling and combining research questions. Reducing several hundreds of research ideas/questions to a number that is feasible for scoring, such as 200 or less, is an important step. It requires knowledge of the subject matter and is therefore usually performed by a very small group of process managers. The way questions are phrased, or how broadly they are framed, may influence the responses and could introduce bias at this step.

Ultimately, it should be demonstrated that the publications based on the CHNRI process have at least some impact on health research funders and research communities. This could be achieved through analysis of bibliometric indicators, showing the impact of the CHNRI papers on the research community and comparing the intensity of research on identified priorities before and after each of the exercises was published. More importantly, a series of interviews with research policy makers at key funding institutions should be conducted to learn whether they are aware of the CHNRI method and if they have been using it themselves to set research priorities, or used the results of the conducted exercises in their decision–making.

Opportunities for further development and implementation

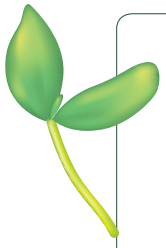
The CHNRI method for setting health research priorities was developed to support decision–making for investments in international child health research at a regional level (low– and middle–income countries). However, its advantages have helped its expansion beyond its initial boundaries. There are clearly many opportunities to implement the CHNRI method to address research priorities relevant to all other population health issues. Moreover, the ease of implementation and low cost should help its implementation at a global, national and sub–national level. The development of a massive open online course (MOOC) in CHNRI implementation may facilitate its wider adoption. Another welcome progress would be the development of a free web–based and mobile phone–based and fully automated CHNRI application platform, which would further simplify the exercise and the computation of scores and agreement statistics, based on widely available spreadsheet software.

Finally, the CHNRI method shows how the area of global health may be particularly receptive to solutions based on "the wisdom of crowds" and crowd–sourcing. The CHNRI exercise could be conducted to set priorities among further ideas for crowd–sourcing–based solutions in global health. The world–wide web, mobile phones and crowd–sourcing could potentially serve to generate a massive amount of useful information in real time and solve a diverse set of problems ranging from coordinating funding support, alerting the development of epidemics, identifying areas of medical supplies shortage, monitoring program implementation over large geographic areas, estimating disease burden, effects of risk factors and impact of implemented health interventions in real–time, and many others.

CONCLUSIONS

Major investment decisions are continuously being made by a variety of funding agencies, but the processes of decision–making and priority setting are rarely systematic and fully transparent. The CHNRI method was developed specifically to address this need. A decade of experience with applying the CHNRI method across a range of contexts and domains has shown that the method is widely acceptable, transparent and replicable. We believe that it has the potential to be scaled up, especially at the national level, and to address health problems outside of child health and nutrition. To encourage its wider use, we will be developing a number of support tools to facilitate its implementation by international, regional, national and local funding agencies.

In the coming years, it will be useful to explore whether the results of the CHNRI method's application, which mainly focused on the context defined by the Millennium Development Goals, would remain relevant to the period until 2030. We will need to explore whether the research ideas/questions identified as priorities remain valid beyond 2015, or do some of the CHNRI exercises need to be repeated with new targets and time horizons? Finally, with an increasing number of the CHNRI exercises being published, and different areas of health research addressed, it should be interesting to explore whether there is an integrated set of priority questions, eg, around implementation models or integration of health system, that can be particularly highlighted as important across most of the conducted exercises? It also remains to be seen whether, as a collective and assisted with modern technology, we could indeed achieve far more to improve global health and development, than we managed to achieve historically through the activities of highly motivated champions.



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REFERENCES

1 Rudan I, Sridhar D. Structure, function and five basic needs of the global health research system. J Glob Health. 2016;6:010505. Medline:26401270

2 Yoshida S, Wazny K, Cousens S, Chan KY. Setting health research priorities using the CHNRI method: III. involving stakeholders. J Glob Health. 2016;6:010303. Medline:27303649 doi:10.7189/jogh.06.010303

3 Yoshida S. Approaches, tools and methods used for setting priorities in health research in the 21st century. J Glob Health. 2016;6:010507. Medline:26401271 doi:10.7189/jogh.06.010302

4 Black RE. The legacy of the Child Health and Nutrition Research Initiative (CHNRI). J Glob Health. 2016;6:010101. Medline:26955468

5 Rudan I, El Arifeen S, Black RE, Campbell H. Childhood pneumonia and diarrhoea: setting our priorities right. Lancet Infect Dis. 2007;7:56-61. Medline:17182344 doi:10.1016/S1473-3099(06)70687-9

6 Rudan I, Chopra M, Kapiriri L, Gibson J, Ann Lansang M, Carneiro I, et al. Setting priorities in global child health research investments: universal challenges and conceptual framework. Croat Med J. 2008;49:307-17. Medline:18581609 doi:10.3325/cmj.2008.3.307

7 Rudan I, Gibson JL, Ameratunga S, El Arifeen S, Bhutta ZA, Black M, et al; Child Health and Nutrition Research Initiative. Setting priorities in global child health research investments: guidelines for implementation of CHNRI method. Croat Med J. 2008;49:720-33. Medline:19090596 doi:10.3325/cmj.2008.49.720

8 Rudan I. Setting health research priorities using the CHNRI method: IV. key conceptual advances. J Glob Health. 2016;6:010501. Medline:27418959 doi:10.7189/jogh.06.010501

9 Rudan I, Yoshida S, Chan KY, Cousens S, Sridhar D, Bahl R, et al. Setting health research priorities using the CHNRI method: I. involving funders. J Glob Health. 2016;6:010301. Medline:26401269

10 Yoshida S, Cousens S, Wazny K, Chan KY. Setting health research priorities using the CHNRI method: II. Involving researchers. J Glob Health. 2016;6:010302. Medline:27350870 doi:10.7189/jogh.06.010302

11 Rudan I. Global health research priorities: mobilizing the developing world. Public Health. 2012;126:237-40. Medline:22325672 doi:10.1016/j.puhe.2011.12.001

12 Shah H, Albanese E, Duggan C, Rudan I, Langa KM, Carrillo MC, et al. Research priorities to reduce the global burden of dementia by 2025. Lancet Neurol. 2016;15:1285-94. Medline:27751558 doi:10.1016/S1474-4422(16)30235-6

13 Surowiecki J. The wisdom of crowds. New York: Random House; 2004.

14 Rudan I, Yoshida S, Wazny K, Chan KY, Cousens S. Setting health research priorities using the CHNRI method: V. quantitative properties of human collective knowledge. J Glob Health. 2016;6:010502. Medline:27350873 doi:10.7189/jogh.06.010502

15 Yoshida S, Rudan I, Cousens S. Setting health research priorities using the CHNRI method: VI. Quantitative properties of human collective opinion. J Glob Health. 2016;6:010503. Medline:27350874 doi:10.7189/jogh.06.010503

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Monitoring and evaluating the adherence to a complementary food supplement (Ying Yang Bao) among young children in rural Qinghai, China: a mixed methods evaluation study

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Background Large investments are currently made in community–based complementary food supplement (Ying Yang Bao, YYB) programs to improve nutrition of young children in rural areas in China. However, there is a lack of knowledge about the experience and challenges of implementing YYB programs in China. We aimed to: 1) monitor distribution of YYB; 2) assess children's adherence to and acceptability of YYB; and 3) evaluate community–based strategies to improve the program.

Methods This mixed methods evaluation study combined data from surveys and focus groups that took place during a controlled interventional evaluation trial. The trial aimed to evaluate the effectiveness of community–based YYB distribution on improving children's health status in rural areas in China. We conducted five cross–sectional surveys with caregivers of children aged 6–23 months (baseline survey (N = 1804) in August 2012 and four follow–up cross–sectional surveys: 1) N = 494 in January 2013; 2) N = 2187 in August 2013; 3) N = 504 in January 2014; and 4) N = 2186 in August 2014) in one rural county in Qinghai Province. We used a two–stage cluster sampling technique to select mothers with eligible children for each survey. Information was collected from caregivers on household characteristics, YYB consumption and acceptability in the surveys. High adherence in each survey was defined as children who consumed at least four YYB sachets during the previous week. A logistic regression model was developed to obtain odds ratios (OR) with 95% confidence intervals of factors associated with high adherence. Also, we conducted 10 focus groups with73 caregivers and health workers involved in the YYB distribution. Content analysis was used to explore qualitative findings, which were used to gain deeper insight into the quantitative results.

Results Around 90% of caregivers had ever received YYB and more than 80% of children ever took YYB. Caregivers mainly knew about YYB through their village doctors. High adherence to YYB increased from 49.4% in the first follow–up survey (January 2013) to 81.4% in the last follow–up survey (August 2014; $P<0.0001$). Repeated training sessions with village doctors could increase adherence. However, due to unplanned YYB stock–out, caregivers did not receive YYB for six months, which may have led to a decrease of high adherence from 64.1% in the second follow–up survey (August 2013) to 53.6% in the third follow–up survey (January 2014; $P<0.0001$). Self–reported acceptability increased from 43.2% to 71.8%, partly due to improving the taste of YYB, which was the main reason that children disliked taking YYB. Unfortunately, more than 60% of caregivers did not perceive positive health improvement in their children after taking YYB. Multivariate analysis showed that children with diarrhea (OR = 1.216, 95% CI 1.025–1.442), cough or fever (OR = 1.222, 95% CI 1.072–1.393) during the past two weeks had significantly lower adherence.

Conclusions This evaluation study showed that program monitoring in rural West China was critically important for understanding program implementation and adherence trends. This led to strategic changes to the intervention over time: improving the taste of YYB; strengthening health education of village doctors and caregivers; and ensuring continuity of YYB supply. Future programs need to monitor program implementation in other settings in China and elsewhere.

Although China has made great achievements in improving children's health during the past two decades, malnutrition of children is still a prominent problem, particularly in poor rural areas [1]. The prevalence of underweight and stunted Chinese children under–five was 8.0% and 20.3% in poor rural areas in 2010, respectively, which is more than two times as the national average. Furthermore, anemia prevalence of Chinese children aged 6–12 months and 13–24 months was 28.2% and 20.5% in 2010, respectively, and did not change between 2005 and 2009 [1]. Therefore, more efforts are still required to improve children's nutrition and health in rural China.

During the last decade, multi–nutrient powders (MNPs), which are home nutrition fortification products, were developed and have been proposed as an important intervention for addressing undernutrition and micronutrient deficiencies among children younger than two years [2]. The efficacy of MNPs in reducing vitamin and mineral deficiencies and improving nutritional status of young children has been well documented in many countries [3-6]. In 2011, the World Health Organization (WHO) developed a guideline on how to use MNPs for home fortification of foods for children aged 6–23 months [7]. Also, MNPs programs are currently being scaled up at a national level in several developing countries, including Bangladesh [8], Mongolia [9], Kenya [5], Nepal [10] and Nigeria [11].

In China, a domestic produced MNP for infant and young children called Ying Yang Bao (YYB) was developed which contains essential fatty acids and protein through inclusion of full fat soy flour as well as multiple micronutrients [12,13]. Each sachet of YYB contained the following: protein (3.0 g), fat (1.0 g), carbohydrate (3.0 g), vitamin A (250 μg),vitamin D_3 (5 μg), vitamin B_1 (0.5 mg), vitamin B_2 (0.5 mg), vitamin B_{12} (0.5 μg), folic acid (75 mg), elemental iron (7.5 mg), zinc (5 mg), and calcium (200 mg). A small–scale efficacy study carried out in Gansu from 2001 to 2004 showed YYB can reduce anemia [14], and improve children's developmental quotient (DQ) [15]. With this evidence on the efficacy of YYB, the Chinese government approved and issued the National Standard for Complementary Food Supplements (GB/T22570–2008) [16] in 2009 and made YYB commercially available on the market [12]. Moreover, YYB was recommended for scale–up in disaster and poor rural areas to improve Chinese children's health. Between 2010 and 2011, free YYB was provided to around 30000 children aged 6–23 months in eight earthquake–affected counties in Sichuan, Gansu and Shaanxi provinces, supported by the United Nations Children's Fund (UNICEF), the United States Centers for Disease Control (US CDC) and China CDC [13] In 2011, the Chinese National Health and Family Planning Commission and All–China Women's Federation initiated a national community–based nutritional program to improve children's nutrition in poor rural areas, which provides free YYB for children aged 6–23 months in poor rural areas [17]. This program was scaled up between 2013 and 2014 [18–20] and until 2014 the program had covered 341 counties in 21 provinces in China, which was estimated to reach more than one million children aged 6–23 months in rural areas [20].

In addition, as a part of Qinghai–Tibet Plateau, the provincial government of Qinghai has also been providing free YYB to all children aged 6–23 months in 15 out of 34 poor counties in Qinghai Province since 2012, which were consistent with the national program [21]. We carried out a controlled interventional evaluation trial in Qinghai from 2012 to 2014 to evaluate the effectiveness of community–based YYB distribution on improving children's health status in rural areas in China, and reported that community–based complementary food supplements combined with dietary counseling can improve feeding practices and reduce anemia prevalence [22].

Although such a large–scale national nutritional program was carried out in China, no study documented the adherence, program experience and challenges of program with the community–based distribution approach. High adherence to MNPs is critical for achieving the maximum health benefits of the intervention. Based on the controlled interventional trial in Qinghai, this current paper aimed to: 1) monitor distribution of YYB; 2) assess children's adherence to and acceptability of YYB; and 3) evaluate community–based strategies to improve adherence. This will illustrate how monitoring led to strategic changes in the intervention that might be helpful for improvement of larger scale programs in China and elsewhere.

METHODS

Study design and data sources

This current mixed methods evaluation was embedded in the controlled interventional trial in Qinghai [22]. We combined data from surveys and focus groups.

Caregivers and their children aged between 6–23 months were main participants of our evaluation. Monitoring of YYB distribution and evaluation of children's adherence to and acceptability of YYB only took

place in the intervention county in the trial, and therefore the data in this current paper are from the intervention county (**Table 1**). Quantitative data were from five representative cross–sectional surveys, which aimed to assess coverage of YYB distribution, children's adherence to YYB, caregivers' experience with YYB, YYB awareness and lessons learnt from the YYB program. Qualitative data were from ten focus group discussions with local health workers and caregivers to increase our understanding of program implementation. We integrated quantitative and qualitative data to show findings on intervention implementation. Also we compared the qualitative findings with quantitative data to validate the quantitative findings [23]. We first report quantitative data followed by qualitative data for YYB distribution, adherence of children to YYB, caregivers' experience with YYB, YYB awareness and lessons learnt from the YYB program. In addition, we report qualitative data only on difficulties with YYB distribution.

Study setting

The provincial government had already decided to implement the program in 15 counties in Qinghai Province before we designed the trial and therefore we selected one intervention county, Huzhu County, from these counties. We selected the control county, Guinan County, from the remaining 19 counties in Qinghai. For selection, we considered the willingness of the local government to cooperate, and socio–economic conditions between the two counties, including: annual per capita income for rural residents, the adult female literacy rate, and the proportion of piped water coverage.

The intervention county lies in the northeast of Qinghai province, with the area of 3423.9 km^2. It has total population of 370 540, with 93.1% of rural population. There are 19 townships and 294 villages in the intervention county. The annual per capita income of rural residents is ¥ 5691 (US$ 872.43) in 2011 [24].

Quantitative approach

We conducted a baseline survey in August 2012 and four follow–up cross–sectional surveys in January 2013 (mini 1 survey), August 2013 (midterm survey), January 2014 (mini 2 survey), and August 2013 (endline survey), respectively, in the intervention county (**Table 1**). Main caregivers and their children aged between 6–23 months were participants of our evaluation.

Sample size and sampling

The sample size and two–stage sampling procedure were reported in the effectiveness of the controlled interventional study paper [22]. We used a sample size of 1973 in the baseline survey, midterm survey and endline survey, as the data on weight, height and hemoglobin level were collected. However, in the mini 1 and mini 2 surveys, we only collected the data on hemoglobin levels, and thus we used a sample size of 504 in both surveys.

We conducted the surveys in the same villages; this meant that children could be included in more than one survey.

Data collection

We used the adapted Maternal, Newborn and Child Health household survey (MNCH HHS) tool [25] to collect baseline characteristics and follow–up data, which included socio–demographic characteristics, infant and young child feeding, and morbidity status. Trained fieldworkers from the School of Public

Table 1. Sources of monitoring data for consumed complementary food supplement Ying Yang Bao (YYB) intervention

Data source	Participants	Type of research	Date	Number of months after intervention
Baseline survey	Children aged 6–23 months and their caregivers (n = 1804)	Quantitative	August 2012	
Intervention started			September 2012	
Six focus groups	MCH workers in township hospitals (n = 11); village doctors (n = 20); fathers (n = 6), mothers(n = 4), and grandparents (n = 9) of children aged 6–23 months	Qualitative	November 2012	2 months
Mini 1 survey	Children aged 6–23 months and their caregivers (n = 494)	Quantitative	January 2013	4 months
Four focus groups	Mothers (n = 12) and grandparents (n = 11) of children aged 6–23 months	Qualitative	April 2013	7 months
Midterm survey	Children aged 6–23 months and their caregivers (n = 2187)	Quantitative	August 2013	11 months
Mini 2 survey	Children aged 6–23 months and their caregivers (n = 504)	Quantitative	January 2014	16 months
Endline survey	Children aged 6–23 months and their caregivers (n = 2186)	Quantitative	August 2014	23 months
Intervention ended			August 2014	

Health, Qinghai University collected data for the five surveys using smartphones. During each survey, we asked caregivers to first come to village clinics for registration, and then interviewers conducted interviews with caregivers in village clinics.

For the four follow–up surveys, we developed questions on YYB distribution and consumption using information that we obtained from a pilot text messaging survey in October 2012 (see Appendix S1 in **Online Supplementary Document**).

Definition of high adherence

The outcome variable adherence was measured through a question in the questionnaire "How many sachets of YYB did your child consumed during the previous week?" High adherence was defined as the proportion of children who consumed at least four YYB sachets during the previous week, which consist with the definition in other studies [6].

Definition of YYB acceptability

Children's acceptability was measured though one question in the questionnaire "How do you think your child like taking YYB? 1=Like very much; 2=Liked; 3=Neutral; 4=Disliked at the beginning, but liked after a while; 5=Disliked, reasons for dislike….; 8=Don't know."

Statistical analysis

Data of each interview was automatically stored as ".txt" form in each smartphone, and we manually transformed and pool each data into a Microsoft Excel (Microsoft, Seattle, Washington, WA, USA) sheet for each survey. After the data cleaning, we converted the database into databasefile (dbf) for the final analysis. We carried out statistical analysis with SAS 9.2 for Windows (SAS Institute Inc., North Carolina, USA). We present the mean and standard deviation (SD) to describe the age of mothers and main caregivers of children, and mean sachets of YYB consumed by children surveyed during the previous week in each survey. We used ANOVA [26] analysis to detect statistically significant differences in age, and T–test to compare differences for the mean sachets. For binary or categorical variables, we present percentages. We used Pearson χ^2–test and Fisher exact test to compare binary and categorical variables. The denominators were all the participants in each survey, including those who answered "Don't/Didn't know" in several questions.

We used logistic regression to identify factors associated with high adherence to YYB. We combined the data from the four follow–up surveys to explore the factors. All relevant factors were first selected by single factor analysis. Multivariate analysis was used to assessed, and only those that were significant included in the final multivariate model are presented. Models were adjusted for the relevant covariates using stepwise regression. We present Odds Ratios (OR) and 95% confidence intervals (CI). We considered two–tailed *P*–values of <0.05 for a significant difference.

Qualitative approach

We conducted 10 focus group discussions in the intervention county to obtain a better understanding of YYB implementation: six in November 2012 and four in April 2013 (**Table 1**).

Sampling

We used convenience sampling. The participants in the focus group were independent from the surveys. .MCH workers came from different township hospitals in the county (1 focus group), village doctors were from different villages in a township (2 focus groups). Caregivers were from the same villages and had a child aged 6–23 months (7 focus groups).

Data collection

One local facilitator from Qinghai Health Education Center and one researcher from Capital Institute of Pediatrics conducted focus group discussions. The study team developed the focus group guides (Appendix S1 in **Online Supplementary Document**). Discussion with MCH workers and village doctors were done at a place convenient for them. Caregivers were invited to village clinics to participate. Discussions were conducted in Mandarin, typically lasting around 30 minutes, and were digitally recorded with the permission of each participant. Tape recordings were transcribed verbatim in Chinese by a medical

student from Qinghai University, and then checked by another medical student by listening to the tapes again to correct any errors. Finally, the study team member who participated in the focus groups validated the transcripts.

Analysis

We conducted content analysis [27] by examining the major themes and patterns that emerged from the data. Two Chinese researchers involved in the study (WQ and DXZ) first read the transcripts and use MAXQDA 11 (VERBI Software GmbH, Berlin, Germany) to organize data along the previously identified key themes independently. Then the researchers compared the themes and discussed areas of agreement and discrepancies. They further refined the themes until consensus was reached on the themes and interpretation of the findings. Finally, WQ translated the themes and related quotes into English and DXZ reviewed the translated themes. We list all the key themes that we identified.

Ethical considerations

The evaluation study was approved by the Ethical Committee of Capital Institute of Pediatrics. All interviewees read the information sheet and provided written informed consent.

RESULTS

Population in quantitative surveys

All caregivers who were invited agreed to participate in the cross–sectional surveys (**Table 2**). Around 30% of children were currently breastfed. Two–week prevalence of cough/fever, and diarrhea were around

Table 2. Characteristics of surveyed caregivers and their children

Surveys	Baseline (N = 1804)	Mini 1 (N = 494)	Midterm (N = 2187)	Mini 2 (N = 504)	Endline (N = 2186)
Children					
Age, % (n)					
6–11 months	33.8 (610)	29.6 (146)	39.6 (866)	25.6 (144)	35.5 (775)
12–17 months	26.8 (484)	41.5 (205)	29.5 (645)	37.7 (190)	29.1 (635)
18–23 months	39.4 (710)	28.9 (143)	30.9 (676)	33.7 (170)	35.5 (776)
Sex, % (n)					
Boy	53.2 (960)	54.3 (268)	55.0 (1203)	58.5 (295)	54.8 (1198)
Girl	46.8 (844)	45.7 (226)	45.0 (984)	41.5 (209)	45.2 (988)
Currently breastfeeding	26.8 (484)	36.2 (179)	27.1 (593)	27.8 (140)	25.3 (553)
Two–week prevalence of cough or fever	49.0 (884)	38.7 (191)	35.3 (772)	43.9 (221)	39.8 (870)
Two–week prevalence of diarrhea	16.7 (302)	17.6 (87)	14.8 (324)	14.5 (73)	15.9 (348)
Mothers					
Age (year), mean (SD)	26.9 (4.9)	27.4 (4.6)	29.1 (11.1)	29.2 (10.4)	28.6 (9.6)
Mother working outside hometown	24.1 (435)	11.9 (59)	26.1 (569)	12.3 (62)	13.6 (515)
Father working outside hometown	39.2 (707)	47.6 (235)	63.9 (1397)	41.1 (207)	57.5 (1257)
Main caregivers					
Relationship with children, % (n)					
Mother	53.2 (960)	64.8 (320)	52.4 (1146)*	58.5 (295)	51.8(1131)†
Father	0.6 (11)	0.8 (4)	0.4 (8)*	3.2 (16)	0.2 (4)†
Grandparent	45.0 (812)	34.4 (170)	46.7 (1020)*	34.3 (173)	47.8(1045)†
Other	1.2 (21)	0.0 (0)	0.5 (12)*	4.0 (20)	0.2(5)†
Age (year), mean (SD)	39.4 (13.7)	36.3(12.3)	40.0 (13.6)*	38.3 (13.2)	38.8(14.1)
Education,% (n)					
Illiterate	41.3(745)	33.4 (165)	40.2 (879)‡	40.1 (202)	40.3(880)†
Primary school	22.0 (396)	23.7 (117)	21.4 (467)‡	17.3 (87)	18.9(414)†
Junior high school	32.0(578)	35.0 (173)	31.5 (689)‡	37.9 (191)	34.1(746)†
Senior high school or above	4.1 (74)	7.3 (36)	5.7 (125)‡	4.6 (23)	5.9(128)†
Do not know	0.6 (11)	0.6 (3)	1.1 (25)‡	0.2 (1)	0.8 (17) †

*One interviewee was missing for this calculation.
†Two interviewees were missing for this calculation.
‡Two interviewees were missing for this calculation.

40% and 15%, respectively. In all five surveys, more than half of the main caregivers were mothers and around 30–40% were grandparents. The mean age of main caregivers was 40 years and around 40% of them were illiterate.

Population in focus groups

A total of 73 people participated in the focus groups: 11 township MCH workers, 20 village doctors, 6 fathers, 16 mothers, and 20 grandparents.

YYB distribution

We found in the four follow–up cross–sectional surveys that most caregivers (around 90%) of children aged 6–23 months in villages had ever received YYB (**Table 3**).Both health workers and caregivers in focus groups said that YYB was mainly distributed by village doctors from September 2012 (after the baseline survey). Once a month, village doctors received YYB from their township hospitals, and then distributed to caregivers through home visits or by asking caregivers to visit clinics through mobile phone calls. Furthermore, YYB was given to children who received vaccinations in the clinics. In some villages, caregivers had to use empty YYB bags and boxes to exchange a new box of YYB to ensure children consumed YYB they had received. Due to different number of children in different villages, it took village doctors one to seven days to distribute YYB for one round. Every month MCH workers went to their catchment villages to monitor YYB distribution while they were undertaking their regular supervision of the basic public health service program.

Although most caregivers of children had ever received YYB, still a small part of caregivers did not receive YYB. **Table 4** shows the distribution of reasons why caregivers did not receive YYB and we found in main reasons for "not received" were "caregivers didn't know the distribution of YYB", and "children were just six months" in four follow–up surveys.

Table 3. Complementary food supplement Ying Yang Bao (YYB) distribution and consumption by children

	Mini 1 (N = 494) (4 months)	Midterm (N = 2186*) (11 months)	Mini 2 (N = 496)† (16 months)	Endline (N = 2186) (23 months)	P1‡	P2§	P3‖
Proportion of children whose caregivers ever received YYB	87.7% (433)	97.1% (2123)	95.6% (474)	99.0% (2164)	<0.0001	0.0746	<0.0001
Proportion of children who ever consumed YYB	82.0% (405)	95.9% (2096)	93.6% (464)	98.1% (2144)	<0.0001	0.0243	<0.0001
Proportion of children who were currently still consuming YYB¶	–	82.3% (1800)	73.1% (363)	92.9% (2032)	–	–	–
Proportion of children who took YYB within the last 24 hours	23.5% (116)	3.3% (1383)	48.2% (239)	78.8% (1722)	<0.0001	<0.0001	<0.0001
Mean (standard deviation) sachets of YYB consumed by children surveyed during the previous week	4.0 (3.0)	4.7 (2.9)	3.9 (3.1)	5.8 (2.2)	0.0002	<0.0001	<0.0001
Proportion of children who had high adherence (consumed 4 sachets of YYB or more)	49.4 (244)	64.1 (1402)	53.6 (266)	81.4 (1780)	<0.0001	0.1824	<0.0001

*Data missing for 1 child.

†Data missing for 8 children.

‡Mini 1 vs Midterm.

§Mini 1 vs Mini 2.

‖Mini 1 vs Endline.

¶We did not ask caregivers this question in the Mini 1 survey.

Table 4. Reasons for "not received complementary complementary food supplement Ying Yang Bao (YYB)"

Reasons	Mini 1	Midterm	Mini 2	Endline
Didn't know the distribution of YYB	28	13	5	4
Children were just six months	12	15	6	5
Not at home when distribution	1	7	0	3
Didn't want YYB	2	0	1	1
There is no YYB in the village clinic	0	2	3	3
Others	4	6	2	1
Didn't know	5	14	25	5

Adherence of children to YYB

In general, the coverage of YYB consumed by children increased with the progress of the YYB program implementation (**Table 3**). The proportion of children who took YYB within the last 24 hours increased from 23.5% in the mini 1 survey to 78.8% in the endline survey ($P<0.0001$); meanwhile, the average sachets children consumed during the previous week increased from 4.0 sachets to 5.8 sachets ($P<0.0001$). The proportion of children who had high YYB adherence (took at least four YYB sachets during the previous week) for each follow–up cross–sectional survey was 49.4%, 64.1%, 53.6% and 81.4%, respectively, which indicated a similar trend. However, there were a significant decrease in all adherence–related indicators between the midterm and mini 2 surveys ($P<0.0001$) (**Table 3**).

In the first mini survey, the main reason why children had never consumed or stopped consuming YYB currently was "Not received"; however, in the last three follow–ups, the main reason changed to "children disliked taking YYB." (**Figure 1**).

In multivariate analysis, higher age of the children (OR=0.976, 95% CI 0.962–0.990), father working outside hometown (OR=0.795, 95% CI 0.692–0.913) were significantly associated with having high adherence (**Table 5**). However, had diarrhea (OR=1.216, 95% CI 1.025–1.442), had cough or fever (OR=1.222, 95% CI 1.072–1.393) during the past two weeks were associated with having low adherence.

Moreover, caregivers also reported that the most common situation in which they temporarily skipped sachets of YYB to their children was because children got cold or diarrhea (**Figure 2**). The proportions of children who temporarily skipped sachets of YYB due to sickness were higher in the mini 1 and mini 2 surveys which were undertaken in January, compared to the midterm and endline surveys which were undertaken in August. In addition, the proportion of caregivers who skipped sachets of YYB to their children because of forgetting increased throughout the four follow–up surveys.

"*Not feed (YYB) when my child got a cold, (I am) afraid that YYB could not be given with medication for a cold together.*" (a grandparent, focus group in April 2014)

YYB acceptability

Figure 3 shows that most children's perceptions on YYB were either "neutral" or "like" YYB. The proportion of children who liked taking YYB increased over time; at the time of the endline survey more than 70% caregivers reported that their children liked taking YYB. The most common reason for disliking YYB reported by caregivers were that children disliked the taste of YYG 50.9% (27/53) in the Mini 1 survey, 57.2% (179/313) in the midterm survey, 86.0% (43/50) in the Mini 2 survey, and 67.6% (48/71) in the

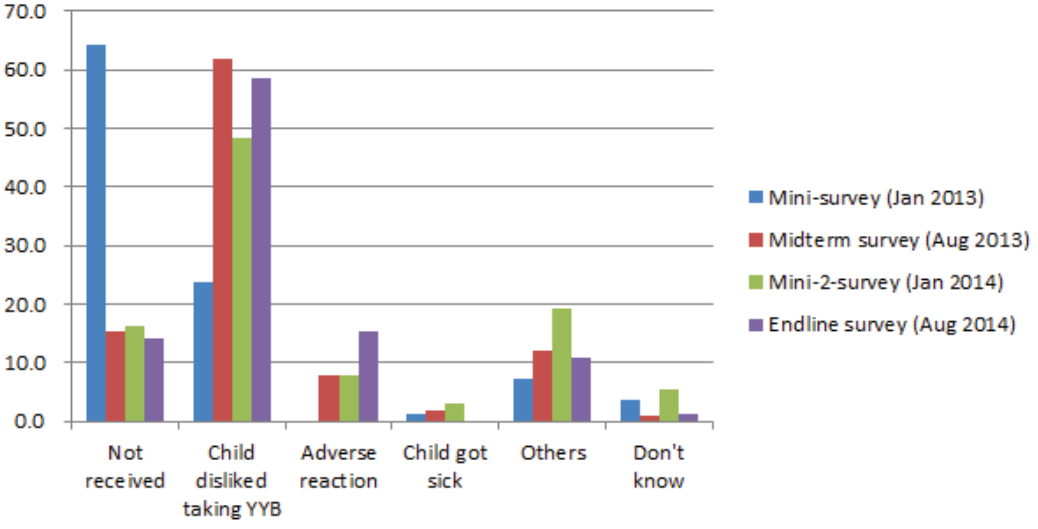

Figure 1. Reasons children had never consumed complementary food supplement Ying Yang Bao (YYB). The denominator of this figure were the numbers of caregivers whose children had never received or consumed YYB or stopped consuming YYB currently, with 89, 386, 133, 154 in each follow–up survey, respectively.

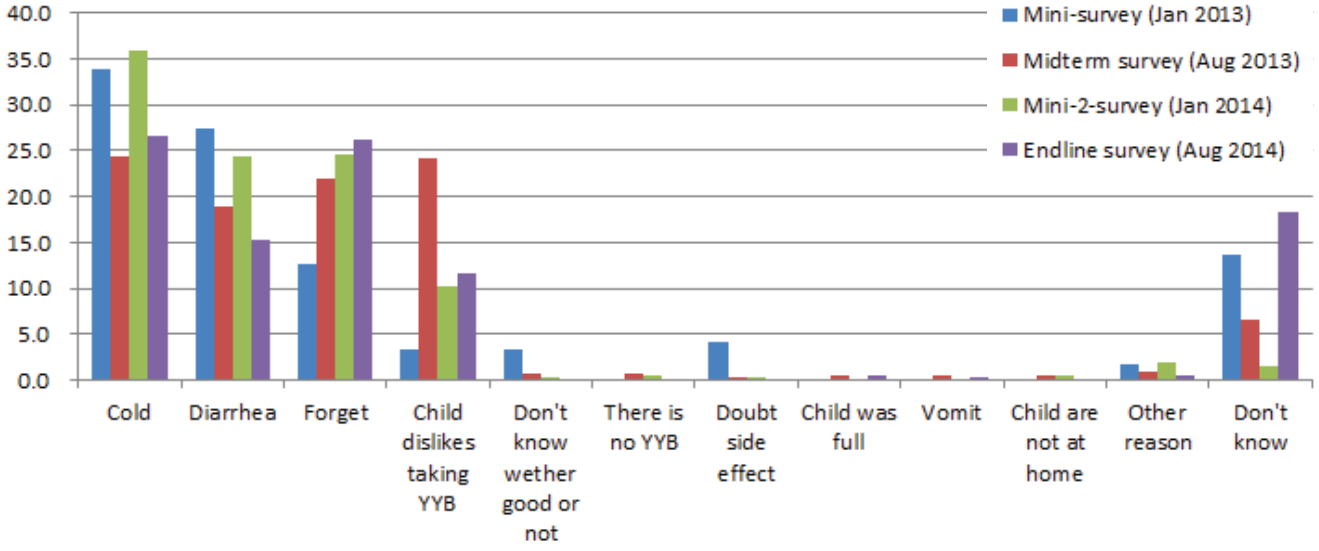

Figure 2. Situations where caregivers temporarily skip sachets of consumed complementary food supplement Ying Yang Bao (YYB) to their children. The denominator of this figure is the numbers of caregivers whose children are still consuming YYB.

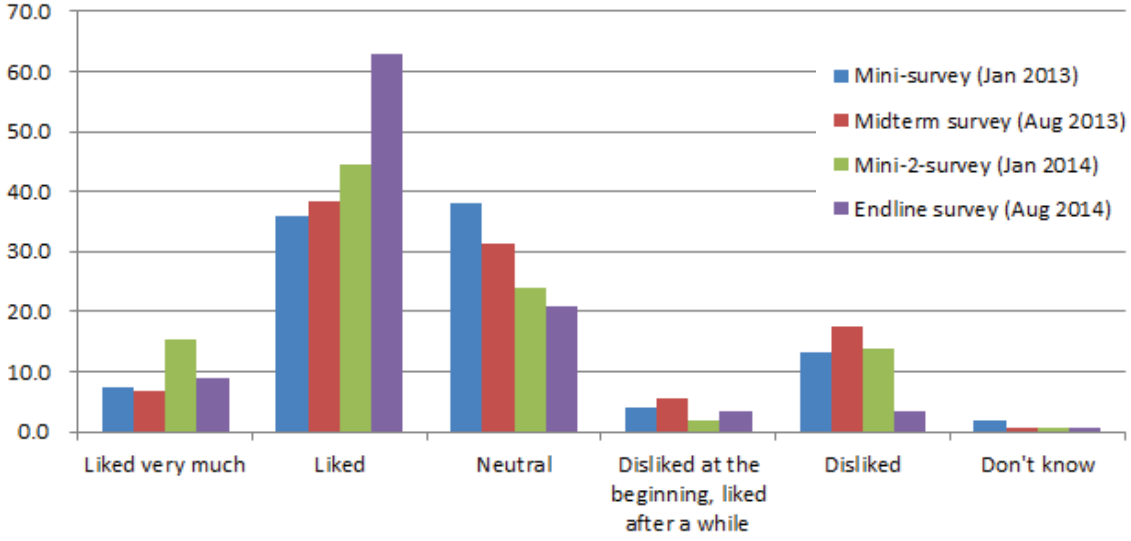

Figure 3. Caregivers' perception of child acceptance of consumed complementary food supplement Ying Yang Bao (YYB) in the follow–up surveys. Caregivers' experience with YYB.

endline survey). Other reasons were: "did not know why children disliked taking YYB", "nausea and vomit", and "diarrhea".

In all focus groups, MCH health workers, village doctors and caregivers said that the taste of YYB should be improved. Some caregivers said that their children did not like taking YYB just to the soybean taste and smell. They suggested that it should be changed into a sweeter taste that children like, by for example adding some sugar.

"*The critical problem is that the taste of YYB is not good, and children are not willing to consume. (YYB) tasted like soybean milk powder. Children even refused eating meals, when YYB added to their meals.*" (a village doctor, focus group in November 2013)

In all follow–up surveys, more than 60% of caregivers did not perceive any change in their children after they started giving YYB to their children (**Table 6**). However, only less than 20% of caregivers had per-

Table 5. Factors associated with high adherence to complementary food supplement Ying Yang Bao (YYB)

Factors	β	Wald	*P*–value	OR (95% CI)
Age of child (months)	–0.0244	10.5029	0.0012	0.976 (0.962, 0.990)
Main caregiver:				
Mother – grandparents	0.1271	0.7757	0.3785	1.136 (0.856, 1.507)
Mother – father	0.4695	1.0964	0.2951	1.599 (0.664, 3.851)
Mother – others	0.0063	0.0001	0.9904	1.006 (0.769, 1.030)
Age of main caregiver (years)	–0.0063	1.6150	0.2038	0.994 (0.984, 1.003)
Main caregiver attend middle school or above	0.1188	2.3153	0.1281	1.126 (0.966, 1.312)
Mother working outside hometown	–0.1161	1.2767	0.2585	0.890 (0.728, 1.089)
Father working outside hometown	–0.2293	10.5547	0.0012	0.795 (0.692, 0.913)
Main income source of family was work	–0.1163	2.4428	0.1181	0.890 (0.769, 1.030)
Child was currently breastfed	0.0982	1.2669	0.2603	1.103 (0.930, 1.309)
Diarrhea	0.1958	5.0589	0.0245	1.216 (1.025, 1.442)
Cough and fever	0.2005	9.0021	0.0027	1.222 (1.072, 1.393)
Surveys:				
Midterm – Mini 1	–0.4450	16.6102	<0.0001	0.641 (0.517, 0.794)
Mini 2 – Mini 1	–0.0771	0.3110	0.5770	0.926 (0.706, 1.214)
Endline – Mini 1	–1.3838	148.7340	<0.0001	0.251 (0.201, 0.313)

OR – odds ratio, CI – confidence interval

Table 6. Mothers' experience with complementary food supplement Ying Yang Bao (YYB)*

Variables (N = 78)	Mini 1 (N = 405) % (n)	Midterm (N = 1800) % (n)	Mini 2 (N = 363) % (n)	Endline (N = 2030) % (n)	*P*1†	*P*2‡	*P*3§
No changes observed	63.5 (257)	61.7 (1110)	64.2 (233)	74.7 (1517)	0.5025	0.8334	<0.0001
Perceived changes in child's health after feeding YYB:							
Positive weight gains	19.0 (77)	18.4 (331)	12.1 (44)	12.1 (246)	0.7703	0.0089	0.0002
Positive height gains	7.2 (29)	7.2 (130)	3.9 (14)	5.2 (106)	0.9654	0.0585	0.1195
Increased appetite	9.6 (39)	8.2 (147)	8.8 (32)	7.7 (156)	0.3385	0.6973	0.1879
Prevented diseases	13.1 (53)	16.7 (300)	8.3 (30)	12.0 (244)	0.0758	0.0316	0.5492
Increased cognitive ability	0.5 (2)	3.6 (64)	1.9 (7)	3.3 (66)	0.0011	0.0651	0.0021

*The denominator of this table were the numbers of caregivers whose children were still consumed YYB currently.

†Mini 1 vs Midterm.

‡Mini 1 vs Mini 2.

§Mini 1 vs Endline.

ceived positive weight gains and diseases prevented in their children; less than 10% of caregivers perceived positive height gains, increased appetite and improved children's cognitive ability.

Several caregivers in focus groups mentioned that the appetite, growth, immunity of their children had improved and less colds occurred after eating YYB; however, some caregivers said it was too short to see any changes in their children.

"*My child is heavier than before, and he has never got cold, even if I took him out every day. Now he is nine months, but he is able to walk by holding something, and grasp things himself.*" (a grandfather, focus group in November 2013)

YYB awareness

In the follow–up surveys, the proportion of caregivers who reported that they had ever received the information on YYB increased from 43.5% in the mini–1 survey to 64.1% in the endline survey. Village doctors were the first source of YYB information and caregivers who received YYB information from village doctor were around 80% in each survey (**Figure 4**). The other major source of YYB information was YYB box, and the proportion of caregivers reporting that they ever received YYB information from the box increased throughout the four follow–up surveys.

Qualitative data showed that village doctors played very important roles in YYB health education. *"Village doctor told me that YYB can provide calcium, iron, zinc and vitamins to children"* (a grandfather, focus group in November 2013).

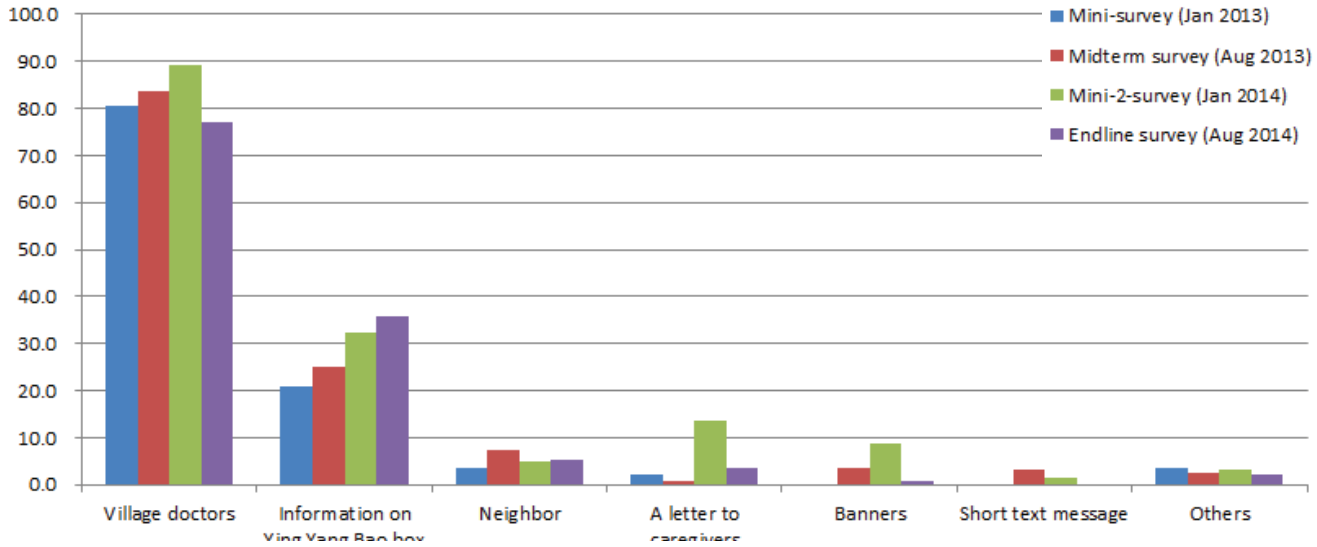

Figure 4. Source of caregivers' information on consumed complementary food supplement Ying Yang Bao (YYB).

When distributing YYB to caregivers, village doctors encouraged them to give YYB to their children. Some village doctors demonstrated in their clinics to caregivers how to give YYB to children.

"*When I came to the village clinic to bring YYB, the village doctor told me the benefit of YYB. After I came back home, I read from the introduction book [on the YYB box].*" (a mother, focus group in November 2013)

Difficulties with YYB distribution

MCH workers from township hospitals in the intervention county generally agreed that more than half of the village doctors in their townships had a positive attitude toward YYB distribution; however, some village doctors also made complaints.

"We are very busy, and still have to distribute YYB."

"Although we work very hard on YYB distribution, caregivers are ungrateful." (a village doctor, focus group in November 2013)

Village doctors indicated that several caregivers in the villages were uncooperative and reluctant to feed their children YYB or some children disliked taking YYB.

"*There is a grandmother in my village who did not feed YYB to her grandchild. I called her for three times to encourage her to feed, but she still told me her child disliked taking YYB.*"

In addition, there was no allowance on YYB distribution for health workers. Several village doctors said that the YYB distribution increased their work load. Every month, they had to use two to four working days to inform of caregivers and distribute YYB. Sometimes they had to bring YYB door to door if caregivers did not come to village clinics. Village doctors had to pay all the fees for calls and transportation during the YYB distribution. Both MCH workers and village doctors asked whether village doctors could be given allowance.

Lessons learnt from YYB program implementation

We initially developed a leaflet called "a letter to caregivers", which contained a detailed description of YYB benefit and usage. However, at the baseline survey (August 2012) we found that more than 40% of main caregivers were illiterate. Therefore, we encouraged village doctors to deliver YYB information through face–to–face counseling and we modified the leaflet by adding more pictures to replace the text description. However, only less than 10% of caregivers reported that they got information of YYB from the leaflets in four follow–up surveys (**Figure 4**).

After the first two months of program implementation, we carried out focus groups with MCH health workers, village doctors, and caregivers of children. The following problems were identified: children disliked the taste of YYB; children refused to take YYB; stopped giving YYB when their children got sick; and side effects, such as diarrhea after children took YYB.

In the first mini survey (4 months after intervention start, January 2013), we found that 61.3% of caregivers temporarily skipped sachets of YYB to their children when they were sick (cold or diarrhea) (**Figure 2**), and 17.0% of mothers reported that their children disliked consuming YYB (**Figure 3**). Also, 12.6% of caregivers sometimes forgot to give YYB (**Figure 2**) and 12.3% of caregivers did not receive YYB (**Table 3**). Therefore, additional training was conducted in March 2013 to train the village doctors in Qinghai YYB project counties to help them with dealing with those problems. Moreover, we used leaflets, banners, calendars and posters to promote the program.

In the midterm survey (11 months after intervention start, August 2013), no new program problems were identified (August 2013).However, caregivers who forgot to give YYB and children who disliked YYB significantly increased to 22.0% ($P<0.001$, **Figure 2**)and 23.1% ($P=0.008$, **Figure 3**), respectively . Therefore, we continued encouraging village doctors to explain again the benefit of YYB, with a focus on caregivers who forgot to give YYB and children who disliked YYB. Meanwhile, banners, calendars and posters were still be used.

In September 2013, there was a stock–out of YYB without further provision from the provincial health department, because a new lengthy approval procedure for YYB procurement was in process. As YYB is a governmental program, purchasing YYB is regulated under a complex and strict process after every 12 months of intervention implementation to ensure the good quality and reasonable pricing. As a result, YYB provision had to be stopped from September to October 2013. We frequently communicated with the county MCH hospital in the intervention county to monitor the process of implementation. To make sure the program was continuously implemented, UNICEF decided to provide YYB to the intervention county for two months from November to December 2013. However, in January and February 2014 YYB was still unavailable, because the approval procedure had not been completed yet.

In the Mini–2 survey (16 months after intervention start, January 2014), the percentage of children who took YYB within the last 24 hours and high adherence significantly decreased as a result of the YYB stock–out (**Table 3**). We coordinated with provincial health department to speed up the approval procedure. Also we requested the manufacturer to improve the taste of YYB.

After governmental approval, the YYB supplier changed from "Tian Tian Ai (天添爱)" to "Fu Ge Sen (福格森)" and YYB was re–supplied from March 2014 onward. In June 2014, we carried out a three–day training sessions to retrain all the village doctors in the intervention county to strengthen their YYB related knowledge, health education and complementary feeding skills. Most village doctors in the training sessions said that the taste of the new YYB was much better than before and that children in their village liked YYB more which was reflected by a decrease in the proportion of children who disliked YYB at the time of the endline survey in August 2014 (23 months later survey) (**Figure 3**). Also at the endline survey high adherence to YYB increased significantly (**Table 3**). However, because the proportion of caregivers who forgot to give YYB continuously increased (**Figure 2**), we advised the local MCH hospital to continue using multiple channels to promote caregivers' awareness of the program.

DISCUSSION

Currently, the Chinese government invests more than ¥500 million RMB (US$ 75.24 million) yearly to implement the community–based complementary food supplement program (YYB program) to improve children's health in rural counties in China since 2014 [18]. However, there was no data published on YYB program implementation experiences and challenges in China. Although our study was only carried out in one Chinese rural county, it provides an important insight into successfully implementing a community–based complementary food supplement program in China. The coverage of YYB distribution was high; the majority of caregivers ever received YYB and most children ever took YYB, which indicated that YYB was efficiently delivered to caregivers in the program county by the multi–tiered distribution channel. A previous study in earthquake–affected areas in China also proved the distribution system from manufacturer to MCH hospitals to township clinics, then to village doctors could guarantee the receipt of YYB [13]. Generally, children's adherence to YYB increased over time in our study, and the proportion of high adherence got to 81.4% at the endline survey. Caregivers reported children's acceptability to YYB

increased over time as well, and the main reason for dislike was the taste of YYB. Therefore, we requested the YYB manufacturer to improve the taste of YYB, which appeared to result in children liking YYB better and taking more doses. Unfortunately, more than 60% of caregivers did not perceive positive health improvement in their children after taking YYB. More than 60% of caregivers who ever received YYB were given information on YYB and the main information sources were village doctors and YYB boxes.

Program monitoring is critical for understanding program implementation and enabling more strategic implementation [28,29]. In our study, we carried out both quantitative and quantitative interviews to monitor the program for two years, which provided us dynamic and comprehensive information on program implementation and allowed us to make real–time modifications. For example, when we found more than 40% of main caregivers were illiteracy at the baseline survey, we changed the text information on the leaflet into the pictures, which was easy for illiterate caregivers to understand. Although we also used leaflets, calendar, banners, posters and blackboards to promote the program, most caregivers reported they received information on YYB from village doctors in each survey, which indicated that well–trained village doctors played an important roles in successful program implementation. Therefore, distribution of YYB as well as health education relied mainly on village doctors. We repeatedly undertook quality training sessions for raising awareness and educating village doctors and caregivers [29]. When monitoring data showed that overall adherence to YYB was low, we conducted additional training sessions with village doctors (March 2013 and June 2014), which helped increase the adherence to YYB. Data in the midterm and endline surveys showed that the high adherence to YYB increased after the training.

Interventions like MNP that aim to reduce anemia prevalence in rural communities will only work when high levels of acceptance and adherence are reached [6,30]. Previous studies in other countries showed high adherence (defined as consumption of four sachets or more per week) to daily provision of MNP ranged from 32% to around 90% [6]. Studies of MNP in Bangladesh even found an adherence of 70–100% [30–33]. The highest adherence to MNP in those studies was observed in a study that was conducted in a controlled setting where field workers deliver and monitor the intervention on a regular basis [31]. A study providing daily sprinkles micronutrient powders to children for 2 months had an average of 75% adherence, but only 39% of children took all 60 sachets [34]. Studies found that a longer duration of the intervention decreased people's motivations and adherence [31,35]. Data in our study showed that the high adherence increased from 49.4% in the mini1 survey (January 2013) to more than 80% in the endline survey (August 2014), which indicates that when active program monitoring to address challenges, adherence can increase over time.

We found in our study that children who got cough/fever or diarrhea during the past two weeks had significant lower adherence, which consist with most caregivers' report that they would skip sachets of YYB when their children got cold or diarrhea. Mirak et al. also found in Bangladesh that around 19% of the mothers reported that they skipped a sachet of MMNP because of any children's illness in the past 60 days, and nearly half of those who skipped a sachet of YYB had fever in the past 15 days [30].

In addition, our study suggested that one of the main reasons for poor acceptability and adherence was that children disliked or even refused to eat YYB, which implied that the taste of YYB needed to be improved. A study in Lao People's Democratic Republic also report sprinkles had unpleasant smell and taste [4]. Different to MNP in other counties, Chinese YYB was a full fat soybean powder mixed with multiple micronutrient powder. The soy flavor of YYB may explain that the taste of YYB was unacceptable by some children. A previous study showed that improved YYB which added peanut and sesame could be more acceptable [12].Furthermore, high mineral concentration in MNP sachets could also influence the taste. Therefore, careful attention must be given to the supplements' sensory characteristics during the development process to minimize cases of rejection and to increase adherence to intervention [36].

Real–life program implementation challenges can be hard to predict. It is known that effectiveness of MNP depends on caregivers to be motivated to offer sachets MNP for children properly and without interruption [36]. Experience form Bangladesh MNP program also suggested that maintaining the supply chain of micronutrient powders was one of the key success factors to MNP program [37]. However, in our study YYB was stocked out for twice due to a period of over six months of the complex governmental approval process, which likely will have caused a significant decrease in adherence in the Mini 2 survey. Therefore, uninterrupted flow of MNP to the community has to be maintained in the future as well. Another challenge was that there was a continual increase in the number of caregivers who temporarily stopped giving YYB due to their forgetfulness in our study. The possible reason was that more than half caregivers

expressed they did not perceive improvements in their children's after taking YYB, and the proportion increased over time as well. It is documented that perceived benefits to children's health was one of factors contributed to high acceptability among caregivers [36] and a visible and convincing change in nutrition status of children is another key success factor to MNP program [37]. Studies also indicated that a longer duration of the intervention decreased people's motivations and adherence [31,35]. Additional efforts should be planned in reinforce caregivers' knowledge on the benefits of YYB, such as text message reminder, which has been proved could improve the compliance of caregivers to a home fortification program [38]. Moreover, currently no governmental subsidies are in place to compensate village doctors' time and cost and this is an obstacle to sustainability of the program.

Strengths and limitations

A strength of this evaluation study is that we collected data from four follow–up cross-sectional surveys which showed the trends over time in program implementation. Our evaluation study also has several limitations. First, the main indicator "high adherence to YYB (children who consumed at least four YYB sachets during the previous week)" in this paper was based the caregivers' recalled data during the previous week, which may have recall bias. Previous studies defined "high adherence to MNP" on weekly basis [6] that is "consumption of four sachets or more per week"; however, we could not get the data on weekly basis, the one week data could not completely represent the real consumption during the whole intervention period. Future monitoring could introduce a compliance card similar to an immunization card to keep track of children under the program [30]. Furthermore, this evaluation study took place in one Chinese county and caution is needed when generalizing the findings from this study to other settings. When similar evaluations in different settings are conducted, this data can be compared to our setting in China.

CONCLUSIONS

Monitoring YYB distribution and consumption promoted the YYB program implementation, which could reveal issues affecting adherence to and acceptability of YYB, and direct more strategic implementation. Village doctors were critical to the success of the Chinese community–based YYB programs as they distribute the supplements and educate caregivers; quality training conducted among village doctors could improve the caregivers' awareness of YYB, thus improve children adherence to YYB. Efforts to improve adherence in the community–based complementary food supplements include: improving the taste of the food supplement, strengthening health education of village doctors and caregivers, and ensuring continuity of food supplement supply. Future programs also need to monitor program implementation in other settings in China and elsewhere.

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REFERENCES

1 Ministry of Health China. People Republic of China. National report on nutritional status of children aged 0-6 years. Beijing: Ministry of Health; 2012.

2 Bhutta ZA, Das JK, Rizvi A, Gaffey MF, Walker N, Horton S, et al. Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost? Lancet. 2013;382:452-77. Medline:23746776 doi:10.1016/S0140-6736(13)60996-4

3 Zlotkin SH, Schauer C, Christofides A, Sharieff W, Tondeur MC, Hyder SM. Micronutrient sprinkles to control childhood anaemia. PLoS Med. 2005;2:e1. Medline:15696200 doi:10.1371/journal.pmed.0020001

4 Kounnavong S, Sunahara T, Mascie-Taylor CG, Hashizume M, Okumura J, Moji K, et al. Effect of daily versus weekly home fortification with multiple micronutrient powder on haemoglobin concentration of young children in a rural area, Lao People's Democratic Republic: a randomised trial. Nutr J. 2011;10:129. Medline:22111770 doi:10.1186/1475-2891-10-129

5 Suchdev PS, Ruth LJ, Woodruff BA, Mbakaya C, Mandava U, Flores-Ayala R, et al. Selling Sprinkles micronutrient powder reduces anemia, iron deficiency, and vitamin A deficiency in young children in Western Kenya: a cluster-randomized controlled trial. Am J Clin Nutr. 2012;95:1223-30. Medline:22492366 doi:10.3945/ajcn.111.030072

6 De-Regil LM, Suchdev PS, Vist GE, Walleser S, Pena-Rosas JP. Home fortification of foods with multiple micronutrient powders for health and nutrition in children under two years of age. Cochrane Database Syst Rev. 2011;9:CD008959. Medline:21901727

7 World Health Organization. Use of multiple micronutrient powders for home fortification of foods consumed by infants and children 6–23 months of age. Geneva: World Health Organization; 2011.

8 Karim F, Choudhury N, Pasha A, Hasan K, Hyder SZ, Zlotkin SH. Reaching sprinkles to millions: social marketing strategy for combating childhood iron deficiency anemia. BRAC; Dhaka: 2006.

9 Mongolia World Vision. Effectiveness of home-based fortification of complementary foods with Sprinkles in an integrated nutrition program to address rickets and anemia. 2005. Available: http://www.wvi.org/sites/default/files/Mongolia-Sprinkles-Evaluation-Report-2005.pdf. Accessed: 10 September 2016.

10 Rah JH, dePee S, Kraemer K, Steiger G, Bloem MW, Spiegel P, et al. Program experience with micronutrient powders and current evidence. J Nutr. 2012;142:191S-6S. Medline:22131547 doi:10.3945/jn.111.140004

11 Korenromp EL, Adeosun O, Adegoke F, Akerele A, Anger C, Ohajinwa C, et al. Micronutrient powder distribution through Maternal, Neonatal and Child Health Weeks in Nigeria: process evaluation of feasibility and use. Public Health Nutr. 2016;19:1882-92. Medline:26370070 doi:10.1017/S1368980015002499

12 Sun J, Dai Y, Zhang S, Huang J, Yang Z, Huo J, et al. Implementation of a programme to market a complementary food supplement (Ying Yang Bao) and impacts on anaemia and feeding practices in Shanxi, China. Matern Child Nutr. 2011;7 Suppl 3:96-111. Medline:21929638 doi:10.1111/j.1740-8709.2011.00353.x

13 Huo J, Sun J, Fang Z, Chang S, Zhao L, Fu P, et al. Effect of home-based complementary food fortification on prevalence of anemia among infants and young children aged 6 to 23 months in poor rural regions of China. Food Nutr Bull. 2015;36:405-14. Medline:26612420 doi:10.1177/0379572115616001

14 Wang YY, Chen CM, Wang FZ, Jia M, Wang KA. Effects of nutrient fortified complementary food supplements on anemia of infants and young children in poor rural of Gansu. Biomed Environ Sci. 2009;22:194-200. Medline:19725461 doi:10.1016/S0895-3988(09)60045-3

15 Chen CM, Wang YY, Chang SY. Effect of in-home fortification of complementary feeding on intellectual development of Chinese children. Biomed Environ Sci. 2010;23:83-91. Medline:20514982 doi:10.1016/S0895-3988(10)60036-0

16 Standardization Administration of the People's Republic of China. Chinese standard for fortified complementary food supplements. Beijing: Ministry of Health of the People's Republic of China; 2008.

17 Liu S. Eliminate anemia among infants and young children in China. China Youth Daily; Beijing: 2011.

18 The story of "Ying Yang Bao". [website in Chinese]. Available: http://www.ce.cn/cysc/sp/info/201510/22/t20151022_6779753.shtml. Accessed: 18 August 2012.

19 National Health and Family Planning Commission of the People's Republic of China. Improve nutrition for children in rural areas in 2013: protocol. [website in Chinese]. Available: http://www.nhfpc.gov.cn/fys/s3585/201311/25bcc2db06774177bd30e0bcc516c67e.shtml. Accessed: 8 October 2015.

20 National Health and Family Planning Commission of the People's Republic of China. Improve nutrition for children in rural areas in 2014: protocol. [website in Chinese]. Available: http://www.nhfpc.gov.cn/fys/s3585/201411/254523446f9241a3a3553e19dec77421.shtml. Accessed: 8 October 2015.

21 Gu L. Qinghai will input 2.5 million RMB every year to implement Integrate Early Child Development program. Xinhua News Agency. Beijing. 2011. Available: http://www.gov.cn/jrzg/2011-11/17/content_1996437.htm. Accessed: 18 August 2012.

22 Zhang Y, Wu Q, Wang W, van Velthoven MH, Chang SY, Han HJ, et al. Effectiveness of complementary food supplement and dietary counseling on anemia and stunting in children aged 6-23 months in poor areas in Qinghai Province, China: a controlled interventional study. BMJ Open. 2016;6:e011234. Medline:27799239 doi:10.1136/bmjopen-2016-011234

23 Creswell JW, Plano Clark VL. The nature of mixed methods research. Designing and conducting mixed methods research. Thousand Oaks, CA: Sage; 2007.

24 Qinghai Statistics Year Book. 2010. Beijing; China Statistics Press: 2011.

25 Zhang S, Wu Q, van Velthoven MH, Chen L, Car J, Rudan I, et al. Smartphone versus pen-and-paper data collection of infant feeding practices in rural China. J Med Internet Res. 2012;14:e119. Medline:22989894 doi:10.2196/jmir.2183

26 SAS Institute Inc. The ANOVA Procedure. Available: https://support.sas.com/documentation/cdl/en/statug/63033/HTML/default/viewer.htm#anova_toc.htm. Accessed: 24 April 2017.

27 US Government Accountability Office. Content analysis: a methodology for structuring and analyzing written material. Washington DC; US Government Accountability Office: 1989.

28 World Health Organization. Managing programmes to improve child health. Geneva: World Health Organization; 2009.

29 Suchdev PS, Ruth L, Obure A, Were V, Ochieng C, Ogange L, et al. Monitoring the marketing, distribution, and use of Sprinkles micronutrient powders in rural western Kenya. Food Nutr Bull. 2010;31:S168-78. Medline:20715601 doi:10.1177/15648265100312S209

30 Angdembe MR, Choudhury N, Haque MR, Ahmed T. Adherence to multiple micronutrient powder among young children in rural Bangladesh: a cross-sectional study. BMC Public Health. 2015;15:440. Medline:25925874 doi:10.1186/s12889-015-1752-z

31 Ip H, Hyder SM, Haseen F, Rahman M, Zlotkin SH. Improved adherence and anaemia cure rates with flexible administration of micronutrient Sprinkles: a new public health approach to anaemia control. Eur J Clin Nutr. 2009;63:165-72. Medline:17895911 doi:10.1038/sj.ejcn.1602917

32 Lemaire M, Islam QS, Shen H, Khan MA, Parveen M, Abedin F, et al. Iron-containing micronutrient powder provided to children with moderate-to-severe malnutrition increases hemoglobin concentrations but not the risk of infectious morbidity: a randomized, double-blind, placebo-controlled, noninferiority safety trial. Am J Clin Nutr. 2011;94:585-93. Medline:21715512 doi:10.3945/ajcn.110.009316

33 Hyder SM, Haseen F, Rahman M, Tondeur MC, Zlotkin SH. Effect of daily versus once-weekly home fortification with micronutrient Sprinkles on hemoglobin and iron status among young children in rural Bangladesh. Food Nutr Bull. 2007;28:156-64. Medline:24683674 doi:10.1177/156482650702800204

34 Lundeen E, Schueth T, Toktobaev N, Zlotkin S, Hyder SM. Daily use of Sprinkles micronutrient powder for 2 months reduces anemia among children 6 to 36 months of age in the Kyrgyz Republic: a cluster-randomized trial. Food Nutr Bull. 2010;31:446-60. Medline:20973465 doi:10.1177/156482651003100307

35 Galloway R, McGuire J. Determinants of compliance with iron supplementation: supplies, side effects, or psychology? Soc Sci Med. 1994;39:381-90. Medline:7939855 doi:10.1016/0277-9536(94)90135-X

36 de Barros SF, Cardoso MA. Adherence to and acceptability of home fortification with vitamins and minerals in children aged 6 to 23 months: a systematic review. BMC Public Health. 2016;16:299. Medline:27056182 doi:10.1186/s12889-016-2978-0

37 Afsana K, Haque MR, Sobhan S, Shahin SA. BRAC's experience in scaling-up MNP in Bangladesh. Asia Pac J Clin Nutr. 2014;23:377-84. Medline:25164447

38 Zhou H, Sun S, Luo R, Sylvia S, Yue A, Shi Y, et al. Impact of text message reminders on caregivers' adherence to a home fortification program against child anemia in rural western China: a cluster-randomized controlled trial. Am J Public Health. 2016;106:1256-62. Medline:27077354 doi:10.2105/AJPH.2016.303140

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Diabetes in Shenzhen, China: epidemiological investigation and health care challenges

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Background Understanding epidemiological characteristics of diabetes in a specific population will potentially benefit prevention and control of diabetes and policy–making. This study aimed to investigate the prevalence and awareness of diabetes, as well as its pharmacological, non–pharmacological and primary care management in Shenzhen, China.

Methods A cross–sectional study was conducted. We employed multistage cluster random sampling methods to select the participants. Face–to–face interview surveys were conducted to collect data. A total of 1676 participants completed the survey.

Results We found that the prevalence of diabetes was 4.8%. The prevalence of impaired fasting blood glucose was 6.0%. The prevalence rates of both diabetes and impaired fasting blood glucose increased with age ($P<0.001$), whereas hypertension was strongly associated with diabetes only (odds ratio (OR) = 1.93, 95% confidence interval (CI) 1.15–3.22). The awareness of diabetes was poor (51.9%) and 54.3% of diabetic patients were not being treated pharmacologically. Less than one–third of diabetic patients were undergoing non–pharmacological treatments. Primary care management of diabetes was recorded for only 11.1% of the patients.

Conclusions Although diabetes prevalence in Shenzhen is about a half that of the Chinese average, high prevalence of impaired fasting blood glucose imposes a public health threat and burden to the health care system. Approximately half of the subjects with diabetes are undiagnosed. Our findings highlight the need of public health efforts for primary and secondary prevention, as well as early detection of diabetes. Primary care may be crucial an improved access to medical services and better management of diabetes.

Diabetes is associated with increased mortality from a range of cardiovascular and non–cardiovascular diseases [1]. Statistics from the World Health Organization (WHO) show a rapid increase of diabetes prevalence during the past several decades. The current estimate of diabetes prevalence is 9% worldwide [2]. In 2014, diabetes caused 1.5 million deaths, with low– and middle–income countries disproportionately affected [3,4]. Therefore, diabetes represents a major public health concern worldwide, especially for developing countries [5].

In China, diabetes has also emerged as an important public health problem. Over the past several decades, diabetes prevalence increased sharply, from 0.7% in 1980 [6], to 2.7% in 2002 [7], to 11.6% in 2010 [8]. This implies that China is home to the largest diabetic population in the world. Statistics

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in 2013 showed that approximately one–fourth of worldwide diabetes–related deaths occurred in China [3]. However, there have been no obvious improvements in diabetes awareness, treatment and control, which are crucial to decrease its related complications and its financial burden [9].

Studies have shown that prevalence, awareness, management of diabetes, as well its risk factors are dependent on economy, culture and living regions etc. [10–12]. Shenzhen, China's first Special Economic Zone holding sub–provincial administrative status, situates in the Pearl River Delta region of southern China. Shenzhen is a migrant city with about 70% of its population being migrants living within a total area of 1996.8 km^2. Shenzhen is an important economic powerhouse, and represents one of the most developed area in China. Understanding epidemiological characteristics of diabetes in a specific population will potentially benefit the prevention and control of diabetes and policy–making. The current study aimed to investigate the prevalence and awareness of diabetes, as well as its pharmacological, non–pharmacological and primary care management in Shenzhen, China.

METHODS

Ethics

This study was approved by the Shenzhen Longhua District Center for Chronic Diseases Prevention and Control Ethics Committee.

Study population

This cross–sectional study was a community–based household population survey conducted between April and May 2015. The study included subjects living in Shenzhen ≥6months in the past one year before the survey was performed and aged 18–70 years. Those living in institutions like nursing homes, and members of the regular Chinese Forces, were excluded. Using the formula $n = deff \times u^2 \times p(1-p)/d^2$, where $deff = 1.5$ and $p = 0.05$, we calculated the sample size of 1752 for a 95% confidence level and 2.5% confidence interval. The final sample size was 2000, taking into consideration a 10% non–response rate. This study sampled the participants using a multistage cluster random sampling design. Two of the ten districts were first randomly selected using a simple random sampling approach. Ten neighborhoods were then randomly drawn from each randomly selected district. A total of 20 clusters were randomly selected. All dwellings in each neighborhood were listed and households were sampled employing a systematic random sampling method. The total number of households selected from each district was proportional to the population size of each district. Households were evenly distributed in each neighborhood stratified by district. Each household was contacted to obtain the list of current household members. A Kish method was adopted for participant selection within each household. The overall response rate was 89%.

Data collection procedure

Data were collected using the World Health Organization (WHO) STEPS approach to chronic disease risk factor surveillance [13], which included a questionnaire on socio–demographic characteristics, clinical measurements and a subsequent blood sample for assessment of biochemical parameters. Face–to–face interview survey was adopted for the collection of socio–demographic factors and clinical measurements. The survey was conducted by specially trained interviewers. The participants were assured of anonymity and confidentiality of the survey, and informed consent was obtained before the survey was commenced. The participants were asked about their age, education level, occupation, marital status, registration, monthly household income. The participants were also asked, "Do you smoke in the past month?", "Do you have diabetes diagnosed by a health professional?", "What kind of pharmacological or non–pharmacological approaches are taken for management of diabetes?", and "Are you under primary care management?"

During the interview, anthropometric measurements were obtained. Body weight was measured to the nearest 0.1 kg using a digital scale, and height to the nearest 0.1 cm in the standing position with a portable stadiometer. According to the protocol recommended by the national guidelines for hypertension management, blood pressure was measured using calibrated mercury sphygmomanometer. Two measurements were performed. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were recorded as the means of two measurements. If the difference between the two measurements was larger than 5 mm Hg, an additional measurement was performed and the mean of all three measurements would be recorded. On an appointed date after the interview, blood sample was obtained from participants. Twelve–

hour fasting blood glucose levels were assessed according to WHO standardized fingertip prick tests, using calibrated blood glucose meters and reagent trips.

Key definitions

Diabetes was defined as fasting blood glucose (FBG) ≥7.0 mmol/L, and/or self–reported physician–diagnosed condition, and/or participants' reported drug treatment for diabetes currently. Impaired fasting blood glucose was defined as 5.6 mmol/L≤FBG<7.0 mmol/L.

Awareness of diabetes referred to participants' self–report of any previous diagnosed condition by health professionals, and/or the use of insulin or medication for diabetes.

Pharmacological management was defined as a participant's report of medication use for diabetes regularly or insulin injection for diabetes.

Non–pharmacological management was defined as changing diet, and/or engaging in exercise, and/or monitoring blood glucose regularly.

Controlled diabetes was defined as FBG<7.0 mmol/L.

Descriptive variables

Socio–demographic information included age, gender, marital status, registration, education level, occupation, monthly household income. The participants were classified into the migrants and the locals, according to the registration. Migrants were defined as individuals who moved to a new location without changing their official Hukou registration [14]. Monthly household income was categorized into three groups according to the monthly household poverty line (RMB 5000, US$ 725) and mean monthly household income level (RMB10 000, US$ 1450) in Shenzhen in 2011 [15]. Lifestyle factors included the body mass index, self–reported smoking status and hypertension. Overweight and obesity were defined as an individual's body mass index (BMI) of 24.0–27.9 kg/m^2 and ≥28.0 kg/m^2, respectively, whereas the BMI of ≤18.4 kg/m^2 and 18.5–23.9 kg/m^2 indicated underweight and normal weight, respectively [16]. Current smoking was self–reported and included individuals who smoke occasionally or daily. Hypertension was defined as self–reported physician–diagnosed condition and currently under antihypertensive treatment, and/or systolic blood pressure (SBP) ≥140mmHg and/or diastolic blood pressure (DBP) ≥90 mm Hg.

Statistical analysis

Socio–demographic characteristics and lifestyle factors of participants were presented as percentages or means (SD). Prevalence estimates of impaired fasting blood glucose and diabetes were computed according to socio–demographic and lifestyle characteristics. χ^2–tests were performed for comparison between participants with different socio–demographic and lifestyle characteristics. Two multivariate logistic regression models were constructed for the calculation of odds ratios (ORs) and 95% confidence interval (CI) to estimate the strength of associations between socio–demographic and lifestyle factors and impaired fasting blood glucose and diabetes. Model fittings were conducted using backward elimination, with a threshold of 0.10 for variable inclusion in the model. Awareness, management and control of diabetes were presented as prevalence rates. A P value <0.05 was considered statistically significant. All analyses were performed by using the SPSS 19.0 software (SPSS Inc., Chicago, IL, USA).

RESULTS

Characteristics of participants

Approximately three–fourths of the participants were aged between 18 to 44 years, and migrants. More than half of participants were women. The majority of participants were married or living with a partner (88.1%). Around one–third of the participants had middle-school education, and just over 10% had primary school or below. More than one–third of the participants were in the middle–income group, whereas 33.1% of participants rejected to answer the question or did not know their monthly household income. Mean SBP was 119.81 mm Hg, while mean DBP was 77.63 mm Hg. The prevalence of hypertension was 17.6%. Mean BMI was 23.50 kg/m^2. Around two–fifths of the participants were overweight or obese. Approximately one–fifth of the participants were current smokers. Mean FBG was 4.81 mmol/L (**Table 1**).

Table 1. Characteristics of participants

Characteristics	No.	Unweighted %
Age (years), mean (SD):	1675	39.26 (11.13)
18–44	1179	70.3
45–59	393	23.4
≥60	103	6.1
Gender:		
Male	791	47.2
Female	885	52.8
Registration:		
Locals	442	26.4
Migrants	1216	72.6
Marital status:		
Never in union	149	8.9
Married or living with partner	1476	88.1
Widowed, divorced and separated	42	2.5
Education:		
Primary school and below	231	13.8
Middle school	603	36.0
High school and equivalent	528	31.5
3–year college and above	306	18.3
Occupation:		
Manual workers	253	15.1
Sales and services	320	19.1
Professional, technical and managerial	214	12.8
Clerical	176	10.5
Other workers	251	15.0
Not working	456	27.2
Household income:		
Low	170	10.1
Middle	606	36.2
High	346	20.6
Rejected	172	10.3
Do not know	382	22.8
Hypertension:		
Yes	295	17.6
No	1381	82.4
SBP, mean (SD)	1676	119.81 (15.65)
DBP, mean (SD)	1676	77.63 (10.79)
BMI, mean (SD)	1665	23.50 (3.71)
Underweight/normal weight	996	59.4
Overweight/obese	680	40.6
Current smoking:		
Yes	366	21.8
No	1310	78.2
Fasting blood glucose (mmol/L)	1676	4.81(1.55)

SD – standard deviation, SBP – systolic blood pressure, DBP – diastolic blood pressure, BMI – body mass index

Table 2. Age–specific prevalence of impaired fasting blood glucose and diabetes

Age group	Impaired fasting blood glucose, No./n (%)	Diabetes, No./n (%)
18–	7/329 (2.1)	1/329 (0.3)
30–	20/617 (3.2)	10/617 (1.6)
40–	27/394 (6.9)	30/394 (7.6)
50–	30/232 (12.9)	29/232 (12.5)
60–70	17/103 (16.5)	11/103 (10.7)

Prevalence of impaired fasting blood glucose and diabetes

The overall prevalence of diabetes was 4.8%. The prevalence rose with age up to 50–59 age group (12.5%, $P<0.001$) (**Table 2**). The prevalence of diabetes was the highest in those widowed, divorced or separated (7.1%, $P=0.040$). The prevalence decreased with education level, and was lowest among those with an education level of 3–year college and above (2.3%, $P=0.030$). There was a significant difference in diabetes prevalence across participants with different occupation, being highest among those not working (7.7%, $P=0.021$). Diabetes was 3 times more frequent in participants with hypertension than their counterparts ($P<0.001$). There was a noteworthy 1.8–fold difference between the participants within different BMI groups (**Table 3**).

The prevalence of impaired fasting blood glucose was 6.0%. The prevalence of impaired fasting blood glucose increased with age, and was highest among those aged ≥60 (16.5%, $P<0.001$) (**Table 2**). Like the prevalence of diabetes, a similar trend was observed for impaired fasting blood glucose across participants with different education levels ($P=0.011$). The prevalence of impaired fasting blood glucose among participants with hypertension was two times higher than that of their counterparts (10.8% vs 5.0%, $P<0.001$). The prevalence of impaired fasting blood glucose in participants who were either overweight or obese was more prevalent when compared with their counterparts (7.6% vs 4.9%, $P=0.021$) (**Table 3**).

The relationships between age and prevalence of diabetes and impaired fasting blood glucose were still statistically significant after adjusting for socio–demographic and lifestyle factors. However, the associations of other socio–demographic factors with prevalence of diabetes and impaired fasting blood glucose were non–significant after similar adjustments were made. The association with hypertension was significant for diabetes even after adjusting for socio–demographic and lifestyle factors (OR = 1.93, 95% CI 1.15, 3.22), whereas the association for impaired fasting blood glucose was not significant (OR = 1.48, 95% CI 0.91, 2.40). Significant relationships between BMI and diabetes (OR = 1.49, 95% CI 0.91, 2.43) and impaired fasting blood glucose (OR = 1.25, 95% CI 0.81, 1.93) were diminished after adjusting for confounding effects of socio–demographic and lifestyle factors (**Table 4**).

Diabetes awareness, management and control

Among 81 participants with diabetes, 42 (51.9%) were aware of their condition. Among all participants with diabetes, 45.7% were treated with medications or insulin, while this percentage was 88.1% among participants with previously diagnosed diabetes. Dietary changes were adopted by 33.3% of participants, while 19.8% engaged in exercise and 23.5% monitored blood glucose regularly. Non-medical management approaches were almost two-fold more common in participants who were aware their condition: 64.3%, 38.1% and 45.2%, respectively. Only over one–tenth of the participants were under primary care management (**Table 5**).

Table 3. Prevalence of impaired fasting blood glucose and diabetes by socio–demographic and lifestyle characteristics

Characteristics	Impaired fasting blood glucose		Diabetes	
	No. (%)	P*	No. (%)	P*
All participants	101 (6.0)	–	81 (4.8)	–
Age group:		<0.001		<0.001
18–44	43 (3.6)		28 (2.4)	
45–59	41 (10.5)		42 (10.7)	
≥60	17 (16.5)		11 (10.7)	
Gender:		0.087		0.860
Male	56 (7.1)		39 (4.9)	
Female	45 (5.1)		42 (4.7)	
Registration:		0.927		0.862
Locals	26 (5.9)		22 (5.0)	
Migrants	73 (6.0)		58 (4.8)	
Marital status:		0.245		0.040
Never in union	5 (3.4)		1 (0.7)	
Married or living with partner	90 (6.1)		76 (5.1)	
Widowed, divorced and separated	4 (9.5)		3 (7.1)	
Education:		0.011		0.030
Primary school and below	21 (9.1)		18 (7.8)	
Middle school	41 (6.8)		30 (5.0)	
High school and equivalent	29 (5.5)		24 (4.5)	
3–year college and above	8 (2.6)		7 (2.3)	
Occupation:		0.209		0.021
Manual workers	14 (5.5)		10 (4.0)	
Sales and services	22 (6.9)		13 (4.1)	
Professional, technical and managerial	9 (4.2)		9 (4.2)	
Clerical	7 (4.0)		3 (1.7)	
Other workers	11 (4.4)		10 (4.0)	
Not working	36 (7.9)		35 (7.7)	
Household income:		0.478		0.297
Low	11 (6.5)		10 (5.9)	
Middle	32 (5.3)		30 (5.0)	
High	17 (4.9)		11 (3.2)	
Rejected	14 (8.1)		6 (3.5)	
Do not know	27 (7.1)		24 (6.3)	
Hypertension:		<0.001		<0.001
Yes	32 (10.8)		32 (10.8)	
No	69 (5.0)		49 (3.5)	
BMI:		0.021		0.005
Underweight/normal weight	49 (4.9)		36 (3.6)	
Overweight/obese	52 (7.6)		45 (6.6)	
Current smoking:		0.219		0.849
Yes	27 (7.4)		17 (4.6)	
No	74 (5.6)		64 (4.9)	

BMI – body mass index

*χ^2–test was used for comparisons.

DISCUSSION

Our study on a representative sample of 1676 participants in Shenzhen, China, found that the prevalence of diabetes was 4.8%. The prevalence of impaired fasting blood glucose was 6.0%. The prevalence rates of both diabetes and impaired fasting blood glucose increased with age, whereas hypertension was strongly associated only with diabetes. The awareness of diabetes was poor and more than half of diabetic patients were not being treated pharmacologically. Less than one–third of diabetic patients were undertaking non–pharmacological treatments. Primary care management of diabetes was reported by only one–tenth of the participants.

This is a representative study with 1676 participants to investigate the epidemiology of diabetes in Shenzhen, China. A high response rate was achieved. Rigorous random sampling approach was adopted and

Table 4. Multivariate analysis on factors associated with prevalence of impaired fasting blood glucose and diabetes

Characteristics	Impaired fasting blood glucose		Diabetes	
	OR (95% CI)*	OR (95% CI)†	OR (95% CI)*	OR (95% CI)†
Age group:				
18–44	1	1	1	1
45–59	2.76 (1.68–4.53)	2.51 (1.51–4.17)	3.48 (1.46–8.33)	2.78 (1.14–6.78)
≥60	4.72 (2.22–10.03)	4.17 (1.94–8.96)	4.15 (2.39–7.20)	3.54 (2.01–6.25)
Gender:				
Male	1.62 (1.02–2.57)	1.56 (0.93–2.65)	1.32 (0.78–2.24)	1.30 (0.72–2.37)
Female	1	1	1	1
Registration:				
Locals	0.98 (0.58–1.65)	0.92(0.52–1.65)	0.91(0.51,1.62)	0.92(0.52,1.65)
Migrants	1	1	1	1
Marital status:				
Never in union	1	1	1	1
Married or living with partner	2.07 (0.49–8.74)	1.97 (0.46–8.41)	3.21 (0.27–38.46)	2.97 (0.25–35.91)
Widowed, divorced or separated	1.22 (0.46–3.20)	1.16 (0.44–3.06)	3.98 (0.53–29.77)	3.62 (0.48–27.25)
Education:				
Primary school and below	2.11 (0.80–5.55)	2.01 (0.76–5.31)	1.23 (0.44–3.48)	1.13 (0.40–3.22)
Middle school	2.25 (0.95–5.36)	2.19 (0.92–5.20)	1.10 (0.42–2.84)	1.02 (0.40–2.64)
High school and equivalent	2.02 (0.87–4.70)	1.96 (0.85–4.57)	1.36 (0.54–3.41)	1.29 (0.52–3.25)
3–year college and above	1	1	1	1
Occupation:				
Manual workers	1.39 (0.60–3.18)	1.39 (0.61–3.21)	0.95 (0.37–2.46)	0.97 (0.38–2.51)
Sales and services	1.04 (0.42–2.54)	1.06 (0.43–2.62)	0.88 (0.32–2.40)	0.91 (0.33–2.49)
Professional, technical and managerial	1	1	1	1
Clerical	1.07 (0.38–3.02)	1.05 (0.37–2.97)	0.50 (0.13–1.99)	0.49 (0.12–1.95)
Other workers	0.70 (0.27–1.81)	0.71 (0.27–1.84)	0.85 (0.31–2.36)	0.88 (0.32–2.44)
Not working	1.05 (0.44, 2.49)	1.06 (0.45–2.54)	1.22 (0.48–3.09)	1.25 (0.49–3.19)
Household income:				
Low	0.89 (0.47–1.68)	0.88 (0.47–1.67)	1.46 (0.69–3.08)	1.44 (0.68–3.04)
Middle	1.05 (0.46–2.40)	1.07 (0.47–2.44)	1.45 (0.56–3.75)	1.51 (0.58–3.93)
High	1	1	1	1
Rejected	1.33 (0.59–3.00)	1.38 (0.61–3.13)	0.88 (0.28–2.70)	0.93 (0.30–2.88)
Do not know	1.01 (0.51–1.97)	0.98 (0.50–1.93)	1.25 (0.56–2.76)	1.20 (0.54–2.66)
Hypertension:				
Yes	–	1.48 (0.91–2.40)	–	1.93 (1.15–3.22)
No	–	1	–	1
BMI:				
Underweight/normal weight	–	1	–	1
Overweight/obese	–	1.25 (0.81–1.93)	–	1.49 (0.91–2.43)
Current smoking:				
Yes	–	0.99 (0.57–1.73)	–	0.89 (0.46–1.73)
No	–	1	–	1

OR – odds ratio, CI – confidence interval, BMI – body mass index
*Model adjusted for age, gender, marital status, registration, education, occupation and monthly household income.
†Model adjusted for age, gender, marital status, registration, education, occupation, monthly household income, hypertension, BMI and smoking status.

Table 5. Awareness, management and control of diabetes

Variables	Among all patients with DM (No., %)	Among aware patients with DM (No., %)	Among patients with DM under drug treatment (No., %)
Awareness	51.9 (42/81)		
Management:			
Pharmacological	45.7 (37/81)	88.1 (37/42)	
Medications	39.5 (32/81)	76.2 (32/42)	
Insulin injection	6.2 (5/81)	11.9 (5/42)	
Non–pharmacological:			
Diet	33.3 (27/81)	64.3 (27/42)	
Exercise	19.8 (16/81)	38.1 (16/42)	
Blood glucose monitoring	23.5 (19/81)	45.2 (19/42)	
Under PC management	11.1 (9/81)	21.4 (9/42)	
Do not know	13.6 (11/81)	26.2 (11/42)	
Control	29.6 (24/81)	57.1 (24/42)	67.6 (25/37)

DMs – diabetes mellitus patients, PC – primary care

implemented. Standard protocols and instruments were employed for blood pressure and blood glucose measurement. We followed the most commonly used international definition of the prevalence, awareness, treatment and control of diabetes to facilitate compatibility with the international literature. Data were collected by specially trained interviewers and supervised using a vigorous quality assurance program. However, the study had some limitations. First, the selection bias might have been introduced without knowing the characteristics of non–respondents, although the response rate was high. Second, data on awareness, pharmacological and non–pharmacological treatments, and primary care management were self-reported. We were not able to construct a criterion standard for rigid validation. Third, the diagnosis of diabetes was based on fasting blood glucose, which may underestimate the prevalence rates of diabetes and impaired fasting blood glucose. Fourth, we did not provide age and gender standardized estimate of prevalence of diabetes due to the unavailability of Shenzhen overall population information with respect to age and gender distribution. Therefore, caution is need for extrapolation of the findings. Last but not least, the cross–sectional nature of the current study does not allow establishing any causal relationships.

The overall diabetes prevalence in Shenzhen was 4.8%, which is in agreement with the 5.2% estimated by the Shenzhen Center for Chronic Diseases Prevention and Control [17]. However, our estimate is lower than that at the national level. The China National Diabetes and Metabolic Disorders Study showed that prevalence of diabetes was 9.7% between 2007 and 2008 [18]. The newest statics in 2010 indicated that the national average prevalence of diabetes was 11.6% [8]. Studies conducted in Beijing and Shanghai, which have economic context similar to that of Shenzhen, also yielded much higher prevalence rates, 9.0% [19] and 15.91% [20], respectively. Younger age of the participants in the current study, which was 39.26 on average, may help to explain the phenomenon, as studies have widely recognized the positive relationship between diabetes prevalence and age [21]. Un–implementation of oral glucose tolerance tests in the current study may have caused misclassifications and subsequent underestimation of diabetes prevalence in the current study [22]. However, it is impractical for large–scale epidemiological studies to adopt oral glucose tolerance tests for diagnosis of diabetes due to limited budget and time [23]. Although we observed lower prevalence of impaired fasting blood glucose than that at the national level (approximately 50% in 2010), its relatively higher prevalence rate than that of diabetes imposes a public health threat and burden to the health care system. Subjects with glucose impairment are at increased risk for developing diabetes, which indicates a substantially greater disease burden. Our findings highlight the importance of both primary and secondary prevention of diabetes, which challenges Shenzhen health care system's capacity and capability.

Both the prevalence rates of impaired fasting blood glucose and diabetes increased with age, which is in line with the reported studies. A number of studies have shown that age is an important risk factor for diabetes [21]. However, the prevalence rate of diabetes in the current study had the peak in 50 to 59 age group, then a decreasing trend was observed, which is in conflict with the national study by Bragg et al. [1]. We also recorded higher prevalence of co–morbid hypertension among diabetic participants, which corresponds to previous reports [24]. Our finding implies that hypertension is a modifiable factor for diabetes, and public health efforts addressing diabetes should include shared, modifiable risk factors for several non–communicable diseases. Generally speaking, reducing blood pressure could reduce the risk of diabetes.

Overweight/obesity and smoking are well known to be closely associated with diabetes [25]. However, these associations were not observed in our study. Some participants may have changed their lifestyles after being diagnosed with diabetes, which might have influenced our results. Potential socioeconomic risk factors for diabetes, including poor education and low–income level, are not observed in the current study, and warrants further investigations.

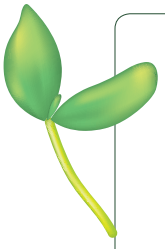
We also showed that the management of diabetes was not optimism, especially the control rate. The diabetes awareness rate in our study was 51.9%, which is almost two times higher the national average in 2010 (30.1%) [8]. However, the awareness rate was lower than that in developed countries like the USA (72% in 2014) [26], which suggests a room for improvement. Although our study showed low pharmacological and non–pharmacological treatment rates in the general population of patients with diabetes, the pharmacological treatment rate was high (88.1%) among participants aware of their disease. Our findings comply with a previous study by Liu et al., which showed that drug treatment rate was 93.5% among diabetic patients who were aware their condition [21]. This implies that early screening may lead to the improvements in management and a decrease the subsequent complications and related social and disease burden. The establishment of health records for every community resident is a part of the national campaign and has been implemented across China, including Shenzhen. Documentation of blood glu-

cose information for everyone may be an alternative for early detection of diabetes and pre–diabetes. Hypertension screening in primary care settings that has been performed in China, such as blood pressure tests for individuals aged ≥35–year who are at high risk of developing hypertension, may shed light on early detection of pre–diabetes or diabetes.

We found that primary care management of diabetes was just over one–tenth of all treatment modalities, although international and national studies have shown the relevance of primary care approach in managing chronic diseases [27,28]. Chronic diseases management is designed to be one of the six integrated services provided by primary care facilities. The Chinese government has also launched guidelines for standardized management of diabetes in primary care. Our study was not designed to test the relationship between primary care management and control rate of diabetes. Whether primary care standardized management of diabetes is an effective approach in reducing blood glucose needs further investigations.

CONCLUSIONS

In conclusion, diabetes prevalence in Shenzhen (4.8%) is about half that of the Chinese average. Age and hypertension are the risk factors of diabetes in Shenzhen population. Approximately half of the subjects with diabetes are undiagnosed. Our findings highlight the need of public health efforts for primary and secondary prevention, as well as for early detection of diabetes. More attention should be paid to the residents aged between 50 and 59 years when formulating intervention strategies. Primary care may be relevant for an improved access to medical services and better management of diabetes.



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Competing interests: All authors have completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available upon request from the corresponding author), and declare no competing interests.

1 Bragg F, Holmes MV, Iona A, Guo Y, Du H, Chen Y, et al. Association between diabetes and cause-specific mortality in rural and urban areas of China. JAMA. 2017;317:280-9. Medline:28114552 doi:10.1001/jama.2016.19720
2 World Health Organization. Global status report on noncommunicable diseases 2014. Geneva: WHO; 2014.
3 WHO. Global health estimates: deaths by cause, age, sex and country, 2000-2012. Geneva: WHO; 2014.
4 GBD 2013 Mortality and Causes of Death Collaborators. Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet. 2015;385:117-71. Medline:25530442 doi:10.1016/S0140-6736(14)61682-2
5 Zimmet PZ, Magliano DJ, Herman WH, Shaw JE. Diabetes: a 21st century challenge. Lancet Diabetes Endocrinol. 2014;2:56-64. Medline:24622669 doi:10.1016/S2213-8587(13)70112-8
6 National Diabetes Research Group. Diabetes mellitus survey of 300,000 in fourteen provinces and cities of China. [article in Chinese]. Zhonghua Nei Ke Za Zhi. 1981;20:678-83. Medline:7341098
7 Liu S, Wang W, Zhang J, He Y, Yao C, Zeng Z, et al. Prevalence of diabetes and impaired fasting glucose in Chinese adults, China National Nutrition and Health Survey, 2002. Prev Chronic Dis. 2011;8:A13. Medline:21159225
8 Xu Y, Wang L, He J, Bi Y, Li M, Wang T, et al. Prevalence and control of diabetes in Chinese adults. JAMA. 2013;310:948-59. Medline:24002281 doi:10.1001/jama.2013.168118
9 Shen H. Effectiveness of a peer-led self-management program for older people with type 2 diabetes in China [dissertation].Brisbane: Queensland University of Technology; 2008.
10 Williams ED, Magliano DJ, Zimmet PZ, Kavanagh AM, Stevenson CE, Oldenburg BF, et al. Area-level socioeconomic status and incidence of abnormal glucose metabolism: the Australian Diabetes, Obesity and Lifestyle (AusDiab) study. Diabetes Care. 2012;35:1455-61. Medline:22619081 doi:10.2337/dc11-1410

11 Yach D, Stuckler D, Brownell KD. Epidemiologic and economic consequences of the global epidemics of obesity and diabetes. Nat Med. 2006;12:62-6. Medline:16397571 doi:10.1038/nm0106-62

12 Agardh E, Allebeck P, Hallqvist J, Moradi T, Sidorchuk A. Type 2 diabetes incidence and socio-economic position: a systematic review and meta-analysis. Int J Epidemiol. 2011;40:804-18. Medline:21335614 doi:10.1093/ije/dyr029

13 Riley L, Guthold R, Cowan M, Savin S, Bhatti L, Armstrong T, et al. The World Health Organization STEPwise approach to noncommunicable disease Risk-Factor Surveillance: methods, challenges, and opportunities. Am J Public Health. 2016;106:74-8. Medline:26696288 doi:10.2105/AJPH.2015.302962

14 Li H, Chung RY, Wei X, Mou J, Wong SY, Wong MC, et al. Comparison of perceived quality amongst migrant and local patients using primary health care delivered by community health centres in Shenzhen, China. BMC Fam Pract. 2014;15:76. Medline:24779564 doi:10.1186/1471-2296-15-76

15 Shenzhen Statistics Bureau, NBS Survey Office in Shenzhen. Shenzhen Statistical Yearbook 2015. Beijing: China Statistics Press; 2015.

16 Yang W, Li H, Fu X, Lu J, Xue Z, Wu C. Inequalities in cardiovascular health between local and migrant residents: a cross-sectional study of 6934 participants in Longhua District, Shenzhen. Medicine. 2015;94:e2103. Medline:26656335 doi:10.1097/MD.0000000000002103

17 Zhou HB, Peng J, Liu XL, Lin HC, Zhang D. Prevalence of diabetes in Shenzhen between 1997 and 2009. [article in Chinese]. Zhonghua Yu Fang Yi Xue Za Zhi. 2011;45:815-9. Medline:22177305

18 Yang SH, Dou KF, Song WJ. Prevalence of diabetes among men and women in China. N Engl J Med. 2010;362:2425-6; author reply 6. Medline:20578276 doi:10.1056/NEJMoa0908292

19 People's Government of Beijing Municipality. Health and population health status report of Beijing city in 2011. [book in Chinese]. Beijing: People's Medical Publishing House; 2012.

20 Qin Y, Wang R, Ma X, Zhao Y, Lu J, Wu C, et al. Prevalence, awareness, treatment and control of diabetes mellitus-a population based study in Shanghai, China. Int J Environ Res Public Health. 2016;13:E512. Medline:27213415 doi:10.3390/ijerph13050512

21 Liu X, Li Y, Li L, Zhang L, Ren Y, Zhou H, et al. Prevalence, awareness, treatment, control of type 2 diabetes mellitus and risk factors in Chinese rural population: the RuralDiab study. Sci Rep. 2016;6:31426. Medline:27510966 doi:10.1038/srep31426

22 Silva-Matos C, Gomes A, Azevedo A, Damasceno A, Prista A, Lunet N. Diabetes in Mozambique: prevalence, management and healthcare challenges. Diabetes Metab. 2011;37:237-44. Medline:21236716 doi:10.1016/j.diabet.2010.10.006

23 Motala AA, Omar MA, Pirie FJ. Diabetes in Africa. Epidemiology of type 1 and type 2 diabetes in Africa. J Cardiovasc Risk. 2003;10:77-83. Medline:12668904 doi:10.1177/174182670301000202

24 Stanifer JW, Cleland CR, Makuka GJ, Egger JR, Maro V, Maro H, et al. Prevalence, risk factors, and complications of diabetes in the Kilimanjaro Region: a population-based study from Tanzania. PLoS One. 2016;11:e0164428. Medline:27711179 doi:10.1371/journal.pone.0164428

25 World Health Organization. Obesity and overweight. 2011. Available: http://www.who.int/mediacentre/factsheets/fs311/en/. Accessed: 5 June 2016.

26 Centers for Disease Control and Prevention. 2014 National Diabetes Statistics Report. 2014. Available: https://www.cdc.gov/diabetes/pubs/statsreport14/national-diabetes-report-web.pdf. Accessed: 8 June 2016.

27 Li H, Wei X, Wong MC, Yang N, Wong SY, Lao X, et al. A comparison of the quality of hypertension management in primary care between Shanghai and Shenzhen: a cohort study of 3196 patients. Medicine. 2015;94:e455. Medline:25654383 doi:10.1097/MD.0000000000000455

28 Hammouche S, Holland R, Steel N. Does quality of care for hypertension in primary care vary with postcode area deprivation? An observational study. BMC Health Serv Res. 2011;11:297. Medline:22047508 doi:10.1186/1472-6963-11-297

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PAPERS

Socioeconomic status and prevalence of type 2 diabetes in mainland China, Hong Kong and Taiwan: a systematic review

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Background China is estimated to have had the largest number of people with diabetes in the world in 2015, with extrapolation of existing data suggesting that this situation will continue until at least 2030. Type 2 diabetes has been reported to be more prevalent among people with low socioeconomic status (SES) in high–income countries, whereas the opposite pattern has been found in studies from low– and middle–income countries. We conducted a systematic review to describe the cross–sectional association between SES and prevalence of type 2 diabetes in Chinese in mainland China, Hong Kong and Taiwan.

Methods We conducted a systematic literature search in Medline, Embase and Global Health electronic databases for English language studies reporting prevalence or odds ratio for type 2 diabetes in a Chinese population for different SES groups measured by education, income and occupation. We appraised the quality of included studies using a modified Newcastle–Ottawa Scale. Heterogeneity of studies precluded meta–analyses, therefore we summarized study results using a narrative synthesis.

Results Thirty–three studies met the inclusion criteria and were included in the systematic review. The association between education, income and occupation and type 2 diabetes was reported by 27, 19 and 12 studies, respectively. Most, but not all, studies reported an inverse association between education and type 2 diabetes, with odds ratios (OR) and 95% confidence interval (CI) ranging from 0.39 (CI not reported) to 1.52 (0.91 – 2.54) for the highest compared to the lowest education level. The association between income and type 2 diabetes was inconsistent between studies. Only a small number of studies identified a significant association between occupation and type 2 diabetes. Retired people and people working in white collar jobs were reported to have a higher risk of type 2 diabetes than other occupational groups even after adjusting for age.

Conclusions This first systematic review of the association between individual SES and prevalence of type 2 diabetes in China found that low education is probably associated with an increased prevalence of type 2 diabetes, while the association between income and occupation and type 2 diabetes is unclear.

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The prevalence of diabetes in China has increased markedly (and much faster than in high income countries) over recent decades [1]. Nationally representative surveys indicate an increase in prevalence of diabetes in China from about 0.9% in adults aged 30 years or older in 1980 to 11.6% in adults aged 18 years or older in 2010 [2,3]. China is thought to have had

the largest number of people with diabetes in the world in 2015, with extrapolation of existing data suggesting that this situation will continue until at least 2030 [4].

Socioeconomic status (SES) is a complex concept that describes the position an individual occupies in the structure of society [5]. It consists of many dimensions and is often measured by using several indicators such as income, education and occupation. SES has been recognized as an important determinant of a population's health [6]. SES is closely linked to a wide range of health problems, including communicable and non–communicable diseases, with different strengths and directions of association in different populations [7–12]. Unlike many risk factors that have consistently shown an association with diabetes across populations, including age, overweight/obesity and physical inactivity, the association between SES and diabetes is not the same in all populations [4,13–15]. In high–income countries, type 2 diabetes is more prevalent among lower than higher socioeconomic groups [10,16–21], whereas the opposite pattern has been found in studies from low– and middle–income countries undergoing rapid economic development [22–25].

Evidence from developed countries indicates that, during the epidemiological transition, noncommunicable diseases occur initially in high SES groups, before appearing in low SES groups [26]. China has experienced extremely rapid economic development over the past 30 years and major economic inequality exists within and between regions, but it is not clear how this is associated with diabetes prevalence [27]. Previous studies have reported inconsistent associations between SES and prevalence of type 2 diabetes in China [28–31]. Understanding the association between SES and diabetes in China is necessary in order to attempt to address socioeconomic health disparities in diabetes as well as for planning approaches to primary and secondary prevention of diabetes in the Chinese population.

To our knowledge, there is no published systematic review of SES and prevalence of type 2 diabetes in China. We conducted a systematic review of cross–sectional studies to describe the association between SES (measured by education, income and occupation) and prevalence of type 2 diabetes in Chinese populations in mainland China, Hong Kong and Taiwan. Chinese people in Hong Kong and Taiwan are genetically similar to their counterparts in mainland China. However, the former are at a more advanced stage of economic development and epidemiological transition, with a larger proportion of people living in urbanised environments and developing related lifestyle habits than in China. Health care systems also differ to that of mainland China [32]. Understanding the association between SES and type 2 diabetes in Hong Kong and Taiwan is useful for helping estimate future diabetes prevalence in urban areas of mainland China.

METHODS

Literature search

This systematic review was conducted using the PRISMA guideline (see checklist in Appendix S1 in **Online Supplementary Document**). The protocol was registered on PROSPERO and can be accessed at *http://www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42016047913*. We carried out a systematic literature search of published studies describing the association between SES and prevalence of type 2 diabetes in mainland China, Hong Kong and Taiwan. We searched Medline (1946–May 2016), Embase (1980–May 2016) and Global Health (1973–May 2016) using a comprehensive search strategy (Appendix S2 in **Online Supplementary Document**). Although the primary reviewers are Chinese, we did not include Chinese databases because other members of the research team, who provided additional review input, are not Chinese speakers. No limits were applied for language or publication time.

Study selection and data extraction

We included cross–sectional population–based studies and baseline surveys of population–based cohort studies which: included Chinese populations in mainland China, Hong Kong or Taiwan aged 18 years or older; reported data on prevalence of type 2 diabetes or odds ratio of type 2 diabetes for populations in different SES groups; defined individual SES exposure as education, income or occupation; and were written in English. We excluded: case–control and hospital–based studies; studies limited to populations selected for specific characteristics such as hypertension or obesity; and non–English language articles. If data from the same study were reported in multiple publications, we applied the following three criteria in the order given, thereby including the publication with either: more information on the association between SES indicators and type 2 diabetes; a greater number of participants; or the most recent publi-

cation date. We did not include longitudinal studies as no longitudinal studies of incidence of diabetes in different SES groups in mainland China were identified in our pilot literature search. We conducted a pilot literature search for longitudinal studies published after 2010 based on a systematic review published in 2011, which reported no studies of incidence of diabetes and SES were identified in China [15].

Two authors (HW and XM) screened the titles, abstracts and (for potentially relevant studies) full text of articles and independently extracted key characteristics for included articles. We extracted information on: author; study year; year of publication; sample size; number of people with type 2 diabetes; demographics; participant selection; study location; SES measures; diabetes diagnosis method; outcome measures (prevalence and odds ratio); and adjustments for potential confounders. Where possible, confidence intervals for prevalence and odds ratio were calculated if they were not reported by authors. For studies reporting several models to estimate the association between SES and diabetes, the result from the model with the most complete adjustment for confounding was chosen. Disagreements were resolved by discussion between the two authors (HW and XM) with a third author acting as arbiter if a decision could not be made.

Quality assessment

Two authors (HW and XM) independently appraised the quality of included studies using a modified Newcastle–Ottawa Scale (NOS) for cohort studies (Appendix S3 in **Online Supplementary Document**) which allows a quantitative assessment of study quality [33]. This scale contains six items, categorized into three dimensions including selection, comparability, and outcome. Within the selection category, a study can be awarded one score for each of the following items: representativeness of the sample; description of the sample; and ascertainment of SES exposures. Within the comparability category, a maximum of two scores were given for the control of confounding factors. Within the outcome category, a maximum of two scores were given for the assessment of the diagnosis of diabetes and one score for the confidence intervals and probability level reported in studies. Each study was scored from 0–8, with a higher score representing higher quality.

Synthesis of study findings

We reported type 2 diabetes prevalence and odds ratios for associations between SES indicators and type 2 diabetes for each of education, income and occupation. For education and income, we presented summary figures showing the prevalence of type 2 diabetes in the lowest and highest SES level and odds ratios of type 2 diabetes for the highest compared with lowest SES level from the model with the most complete adjustment for confounding. Ideally, we would have summarized odds ratios adjusted for age and sex only, but unfortunately few studies reported these minimally adjusted estimates, with most adjusting for additional factors. For studies reporting results only in several subgroups (eg, stratified by age and gender), we presented the result with the largest sample size. It was not possible to summarize the findings for occupation in figures, given the marked heterogeneity in definition of occupation.

For each SES indicator, the full results from each study, including stratification by urban/rural status were summarized in supplementary materials, grouped according to whether studies presented: only prevalence; only odds ratios; and both prevalence and odds ratios, and ranked from high to low quality. These figures and tables were accompanied by a narrative synthesis of the study findings, since heterogeneity between studies precluded meta–analyses.

RESULTS

Selection of studies

The literature search initially identified 3003 studies, with 1935 remaining after de–duplication. Of these, 1771 studies were excluded after title and abstract screening, and 131 further studies were excluded after full text review. Thirty–three studies met the inclusion criteria and were included in the systematic review (**Figure 1**).

Study characteristics

An overview of the characteristics of the included studies is presented in **Table 1**. Twenty–four studies were conducted in mainland China (three in urban areas, five in rural areas and 16 in both urban and

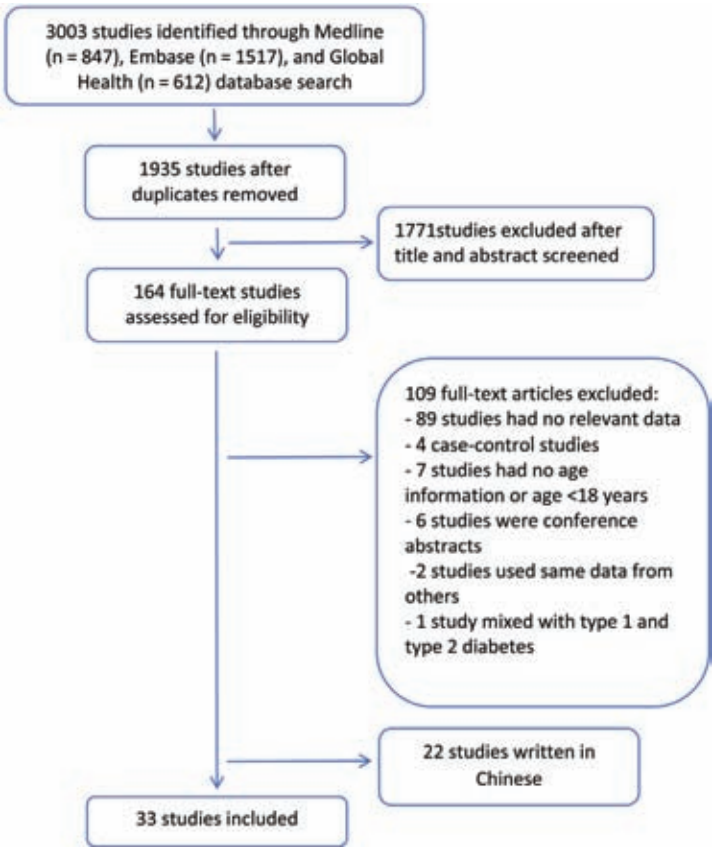

Figure 1. Flowchart of selection of studies in systematic review.

rural areas), three in Hong Kong and six in Taiwan. Study year ranged from 1986 to 2012, with a marked increase in studies on this topic over time, with 24 studies published since 2009. Sample size ranged from 988 [63] to 512 891 [41]. All studies included both men and women, but only five reported the association between SES and type 2 diabetes by sex. Self–reported diabetes and fasting blood glucose were the most commonly used methods to diagnose diabetes. Some studies used an oral glucose tolerance test (OGTT), random blood glucose and postprandial blood glucose for diagnosis of diabetes. Twelve studies provided prevalence of diabetes in different SES groups, 15 studies provided odds ratio of diabetes for different SES groups, and six provided both prevalence and odds ratios.

Quality of included studies

The quality scores of included studies ranged from 4 to 7 with a mean score of 6.0 based on the modified NOS assessment. Two studies had a highly selected study population. One selected the sample from an association for elders to represent the total older population of the study area [50], and a second study included participants who were willing to cooperate with the research team, without using any sampling techniques [52]. Fourteen studies did not report sex or age distribution, which is a limitation since both sex and age are important risk factors for type 2 diabetes [4]. Eight studies only reported crude prevalence of diabetes or unadjusted odds ratio for the association between SES and diabetes [35,42,45,48,49,55,57,61] and five studies defined diabetes solely based on self–reported diagnosis [31,43,47,55,56]. In addition, four studies did not provide confidence intervals or p values for statistical tests [35,41,42,57].

Measures of SES

A single measure of SES was reported in 15 studies, with the remaining studies reporting data for two (10 studies) or three (8 studies) SES indicators. Education was the most commonly used indicator, being reported in 27 studies, and was classified either as highest educational level (in 21 studies) or the number of school years completed. Income was reported in 19 studies, including 15 family income measures and four personal income measures. Occupation was reported in 12 studies, but the measures of occupation differed greatly between studies, with the definition based on: job titles; skills (manual or non–manual); or a simple classification of employed and unemployed.

Association between SES and type 2 diabetes

Among the 27 studies reporting on education and type 2 diabetes, 16 reported prevalence estimates, among which five reported standardized prevalence. Fifteen studies reported odds ratios, 14 of which presented odds ratios that controlled for various potential confounders. Generally, prevalence of type 2 diabetes was higher in those with a lower compare to higher education level (**Figure 2** and Appendices S4 and S6 in **Online Supplementary Document**). Most, but not all, studies reported either a significant inverse association between education level and type 2 diabetes or a possible trend toward such an association, with odds ratios (95% CI) ranged from 0.39 (CI not reported) to 1.52 (0.91, 2.54) for the highest compared to the lowest education level (**Figure 3** and Appendices S5 and S6 in **Online Supplementary Document**). The studies from Hong Kong reported an inverse association [57] and no significant association [55] between education and type 2 diabetes. Among four studies from Taiwan reporting an association between education and type 2 diabetes, two reported an inverse association [49,61], and the other two reported no evidence of an association [58,62]. Among all studies, four studies reported sex–

Table 1. Characteristics of studies identified in systematic review with evaluation of association between prevalence of type 2 diabetes and SES in mainland China, Hong Kong and Taiwan

Study	Study year	Participants selection	Sample, N (diabetes)	Gender (% men)	Age (mean ± SD, years)	Study location*	SES indicator	Diabetes diagnosis method	Outcome measure (prevalence/ odds ratio)	Quality score
Wu et al. 2016 [34]	2007–2011	Using a random multistage stratified sampling method, 2–3 cities within each of 6 provinces from south and north China were selected, from which several communities and villages were randomly selected	23 010 (983†)	46.9	≥18 (43.0, 30.4–56.3)‡	Urban and rural	Education	Self–report or FBG	Prevalence	7
Liu et al. 2016 [35]	2001, 2010	Using a two–stage cluster random sampling method, 9 residential communities were randomly selected in Wanshoulu district in Beijing, from which all households were chosen and one person aged ≥60 was randomly selected in each household	2001: 2277 (487§), 2010: 2102 (521§)	2001: 41.4; 2010: 40.3	≥60 (67.9 ± 5.8 in 2001; 71.2 ± 6.6 in 2010)	Urban	Education	Self–report or FBG	Prevalence	5
Zhou et al. 2015 [36]	2010	Using a multistage probability sampling design, 3 communities or villages were selected in each of 4 subdistricts with probability proportional to size from each National Disease Surveillance Point; within each community 50 households were randomly selected, and one person randomly selected in each household	98 058 (12 237§)	45.7	≥18 (NR)	Urban and rural	Education, occupation	Self–report or FBG or OGTT or HbA1c	Odds ratio	6
Yu et al. 2015 [37]	2012	Using a multistage stratified random cluster sampling method, 32 counties were selected from 9 cities, from which 3 or 4 towns were randomly selected; within each town, 3 neighborhood committers were randomly selected, from each of which one village was randomly selected, before randomly selecting people aged 18 to 79 years	16 834 (1380‖)	45.9	18–79 (42.7 ± 14.5)	Urban and rural	Education, income, occupation	Self–report or FBG	Prevalence	7
Xue et al. 2015 [38]	2006, 2009	Using a stratified random cluster sampling method, people who lived in Qingdao city for at least 5 years in 3 urban areas and 3 rural areas were selected	6894 (360‡)	39.4	35–74 (51.2 ± 10.6)	Urban and rural	Education, income	HbA1c	Odds ratio	7
Xu et al. 2015 [39]	2010–2011	Using a multistage stratified random sampling method, 3 central temples and 3 counties in Chengdu region were selected from each altitude level;4 townships were selected from each county, and within each townships 3 villages were selected, from which all people aged ≥18 were selected	1659 (106‖)	49.5	≥18 (44.0 ± 15.2)	Urban and rural	Education, income	Self–report or FBG or OGTT	Prevalence	7
Bu et al. 2015 [40]	2007–2008	Using a multistage stratified random sampling method, cities within 14 provinces in China were selected, from which 152 city districts and 112 rural villages were randomly selected; people aged ≥20 years who had lived at their current residence for ≥5 years were selected	39 071 (3254‖)	39.2	≥30 (NR)	Urban and rural	Education	Self–report or FBG or OGTT	Odds ratio	6
Bragg et al. 2014 [41]	2004–2008	People aged 30–79 were selected from five urban and five rural areas in China; these were permanent residents identified through official residential and invited by letter after extensive publicity campaigns	512 891 (30 773‖)	41.0	30–79 (NR)	Urban and rural	Education, income	Self–report or FBG or random blood glucose	Prevalence	5
Zhang et al. 2013 [28]	2005	Using a multistage stratified cluster random sampling method, 3 communities were randomly selected from two urban and one suburban district(s) in Tianjin; 3 neighborhoods were randomly selected from each community and all people who had lived in the selected neighborhoods for >5 years and were aged ≥15 years were selected	7315 (688§)	NR	20–79 (NR)	Urban	Education, income, occupation	Self–report or FBG or OGTT	Odds ratio	6
Xia et al. 2013 [42]	2010–2011	Using a stratified random sampling method, 3 communities within each of 4 districts of Haikou were randomly selected, from which 1000 people were selected	12 000 (636§)	51.0	>18 (49.1 ± 0.26¶)	Urban	Education, occupation	FBG	Prevalence	5

Table 1. Continued

Study	Study year	Participants selection	Sample, N (diabetes)	Gender (% men)	Age (mean ± SD, years)	Study location*	SES indicator	Diabetes diagnosis method	Outcome measure (prevalence/ odds ratio)	Quality score
Wu et al. 2013 [43]	2010	Using a probability sampling design and a multistage cluster sampling method, 1 county from rural National Disease Surveillance Points (DSPs) and one district from urban DSPs were selected from 8 provinces, resulting in 64 principle sample units	13157 (868‡)	48.1	≥50 (62.6±0.3)	Urban and rural	Income	Self–report	Both	6
Wang et al. 2013 [44]	2011	Using a multistage stratified random sampling method, all townships within two counties in Yunnan province were selected and within each township 2 villages were randomly selected	4801 (341‖)	44.8	25–86 (51.1)	Rural	Education, income	Self–report or FBG or OGTT	Odds ratio	7
Cai et al. 2013 [45]	2011	Using a multistage stratified random sampling method, 1 county with high wealth and 1 county with low wealth were randomly selected in Yunnan province; people aged ≥18 were randomly selected from 20 villages within each county	9396 (614§)	46.0	≥18 (51.7±19.6)	Rural	Education	Self–report or FBG	Prevalence	6
Yan et al. 2012 [46]	2009	Using a multistage random cluster sampling method, people aged ≥7 were randomly selected from 228 communities in 9 provinces	8458 (NR)	47.1	≥18 (NR)	Urban and rural	Income	FBG or HbA1c	Odds ratio	6
Chen and Chen. 2012 [47]	NR	Using a multistage random cluster sampling method, 2–12 townships were randomly selected from each 23 counties in Taiwan, within which 12–123 neighborhoods were randomly selected; within each neighborhood, 4 households were randomly selected	13741 (NR)	57.0	18–64 (NR)	Taiwan	Occupation	Self–report	Both	6
Shi et al. 2011 [48]	2002	Using a multistage random sampling method, households were randomly selected from 6 counties and 2 cities; all people in the households were selected	2849 (79‖)	45.9	≥20 (47.0)	Urban and rural	Education	FBG	Prevalence	6
Lin et al. 2011 [49]	2004	Using a multistage random sampling method with a sampling rate proportional to size within each stage, 39 Li units were randomly selected from each 8 city districts; people were randomly selected from each sample Li	2332 (284§)	48.6	≥40 (56.9)	Taiwan	Education, income	Self–report or FBG	Prevalence	6
Kavikondala et al. 2011 [50]	2005–2008	People were randomly selected from 'The Guangzhou Health and Happiness Association' who are permanent residents in Guangzhou	19818 (2193‡)	26.7	50–96 (60.4)	Urban	Education, occupation	Self–report or FBG	Odds ratio	6
Fu et al. 2011 [30]	2006–2007	All adult residents aged 18–64 were selected with exclusion of those who were temporary workers or university students not living in the county from four rural communities in Deqing, Zhejiang province	4506 (99‡)	41.4	18–64 (46.1±10.0)	Rural	Education, income, occupation	Self–report or FBG	Both	7
Cai et al. 2011 [29]	2008–2010	Using a multistage stratified random sampling method, 3 counties with low, high and high level of wealth were randomly selected from Yunnan province; all townships in counties were selected and 3 villages in each township were selected by probability proportional to size, from which people aged ≥18 years were randomly selected	10007 (657§)	46.2	≥18 (NR)	Rural	Education, income	Self–report or FBG	Odds ratio	6
Wei et al. 2010 [51]	2005	Using a multistage random cluster sampling, communities were randomly selected from 5 areas in a region in Heilongjiang	1058 (75§)	50.1	>20 (NR)	Rural	Education, income	Self–report or FBG or OGTT	Both	7
Zhou et al. 2009 [52]	2007–2008	People aged ≥20 years in 10 communities in Beijing were selected where their committees would like to cooperate with the research team	2801 (580§)	27.2	35–79 (54.7)	Urban and rural	Education, income, occupation	Self–report or FBG or OGTT	Both	7

Table 1. Continued

Study	Study year	Participants selection	Sample, N (diabetes)	Gender (% men)	Age (mean ± SD, years)	Study location*	SES indicator	Diabetes diagnosis method	Outcome measure (prevalence/ odds ratio)	Quality score
Ning et al. 2009[53]	2001–2002, 2006	Using a stratified random cluster sampling method, people aged 35–74 years living in Qingdao city for at least 5 years were randomly selected from 3 urban districts and 4 rural counties	11 624 (1383‡)	39.6	35–74 (54.4 in 2001–2002; 51.5 in 2006)	Urban and rural	Education, income, occupation	Self–report or FBG or OGTT	Odds ratio	7
Hu et al. 2009 [54]	2000–2001	Using a multistage stratified random sampling method, 1 rural and 1 urban county within each of four provinces from North and 4 provinces from South China were randomly selected; 1 township/street was randomly selected from each county, from which people aged 35–74 years were randomly selected	15 236 (986§)	48.4	35–74 (50.1 ± 0.12¶)	Urban and rural	Education, income, occupation	Self–report or FBG	Prevalence	7
Xu et al. 2006 [31]	2000–2001	Using a multistage random sampling method, 3 urban districts and 2 rural counties were randomly selected in Nanjing, from each of which 3 streets/towns were selected; 3 villages were randomly selected in each street/town, from which people aged ≥35 y who had been a local resident for at least 5 years in each village were selected	29 340 (556§)	49.8	≥35 (NR)	Urban and rural	Education, income, occupation	Self–report	Both	6
Chou and Chi. 2005 [55]	1996	People aged ≥60 years in 6000 households were randomly selected from a continuous sample survey, which use a full list of addresses of quarters in Hong Kong as the sampling frame	2003 (246§)	47.0	≥60 (NR)	Hong Kong	Education	Self–report	Prevalence	4
Yu and Wong. 2004 [56]	NR	Households in Tai Po Hong Kong were randomly selected by telephone survey using a residential telephone directory	2670 (NR)	NR	≥20 (NR)	Hong Kong	Income	Self–report	Odds ratio	5
Woo et al. 2003 [57]	1995–1996	People aged 25–74 from 3 major of Hong Kong were randomly selected by telephone survey	988 (59§)	49.4	25–74 (45.6 ± 11.7)	Hong Kong	Education	FBG or OGTT	Prevalence	5
Chen et al. 2001 [58]	1996–1997	Using a multistage proportional stratified random cluster sampling method, people aged 50–79 years were randomly selected from 3 townships	1293 (182‡)	41.8	50–79 (63.8)	Taiwan	Education	Self–report or FBG	Odds ratio	7
Chen et al. 1999 [59]	1995–1996	Using a proportional stratified random sampling method, people aged 40–79 years were randomly selected from 6 areas	1601 (295§)	48.7	40–79 (57.4)	Taiwan	Occupation	Self–report or FBG	Odds ratio	7
Pan et al. 1997 [60]	1994	People aged ≥25 years were selected from cities and rural areas in 19 provinces	213 515 (4864§)	52.9	25–64 (NR)	Urban and rural	Income	Self–report or FBG or OGTT	Odds ratio	6
Chou et al. 1994 [61]	1991	All people aged >30 years in each village from Kin–Hu Town were selected	3236 (193§)	47.5	>30 (NR)	Taiwan	Education	FBG or OGTT	Odds ratio	5
Tai et al. 1992 [62]	1986	8 subdistricts of Ta–An District in Taipei City and 5 villages of 11 counties of Taiwan Province were randomly selected	11 478 (715§)	50.3	≥40 (NR)	Taiwan	Education, income	Self–report or FBG or postprandial blood glucose or OGTT	Odds ratio	6

SD – standard deviation, Self–report – self–reported history of type 2 diabetes or using medication for type 2 diabetes, FBG – fasting blood glucose, OGTT – oral glucose tolerance test, NR – not reported

*Urban and/or rural are in mainland China.

†Median and interquartile range.

‡Number is estimated based on the crude prevalence of diabetes.

§Number reported in the study.

‖Number is estimated based on the adjusted prevalence of diabetes.

¶Standard error.

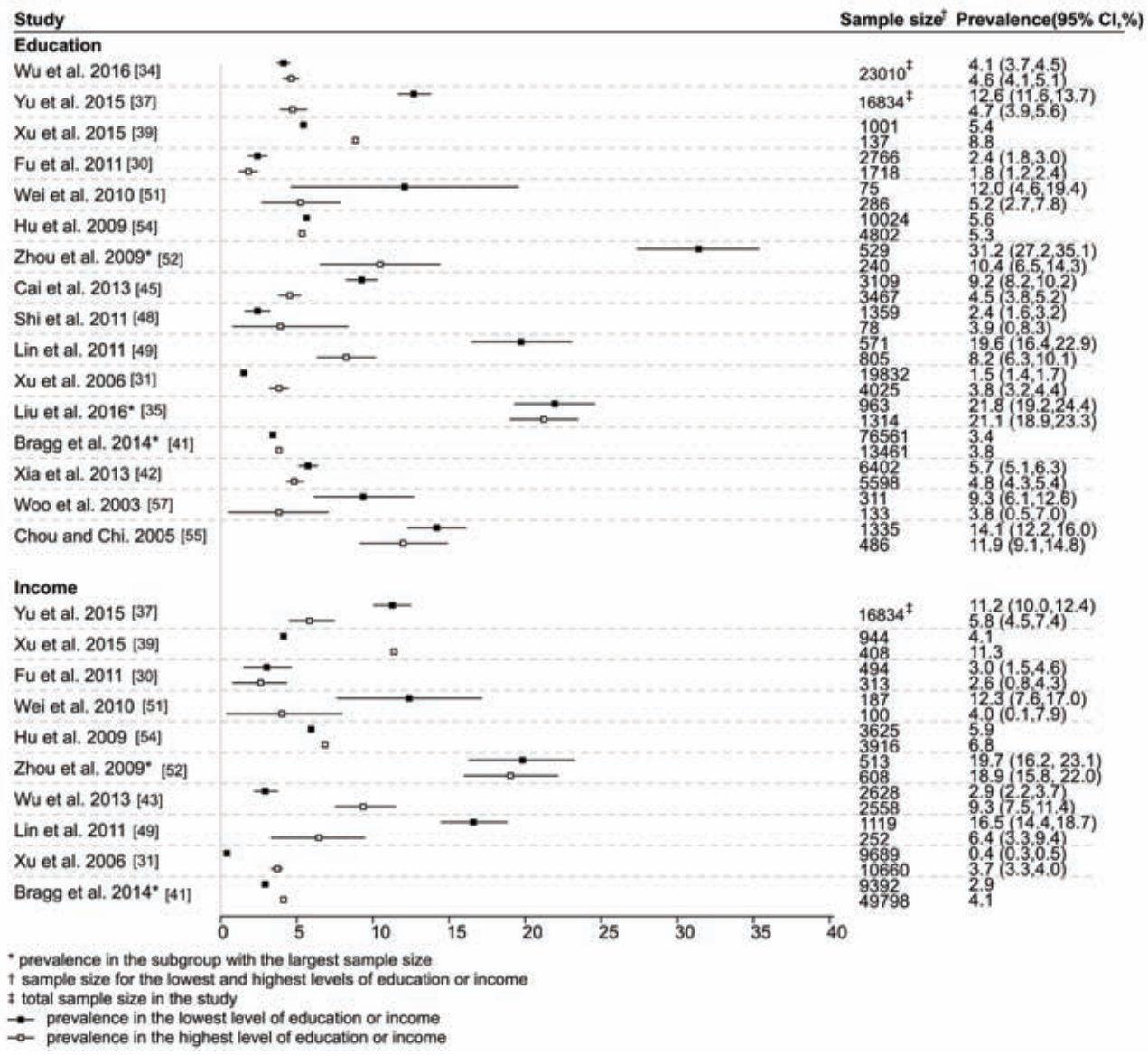

Figure 2. Prevalence of type 2 diabetes in the lowest and highest levels of education and income in included studies.

specific analyses, with two reporting that higher education was associated with increased prevalence of type 2 diabetes among men, with the opposite observed in women [34,52]. The other two studies [39,53] did not find any gender differences in the association between education and type 2 diabetes.

Of the 19 studies reporting on income and type 2 diabetes, 10 reported prevalence estimates, among which four reported a standardized prevalence. Fourteen studies reported odds ratios, all but one of which only presented odds ratios adjusted for various confounders. There was no clear pattern of prevalence of type 2 diabetes by income level across studies, with considerable inconsistency between studies (**Figure 2**, Appendices S7 and S9 in **Online Supplementary Document**). Similarly, among studies reporting odds ratios, the evidence for an association between income level and type 2 diabetes was inconsistent (**Figure 3**, Appendices S8 and S9 in **Online Supplementary Document**). The study from Hong Kong reported an inverse association between income and type 2 diabetes [56]. The studies from Taiwan reported an inverse association [49] and no significant association [62] between income and type 2 diabetes. Among all studies, four studies reported sex–specific analyses, among which Ning et al. [53] found a significant positive association between income and type 2 diabetes only in men in rural areas. Zhou et al. [52] and Yan et al. [46] also found a positive association in men but not in women. A fourth study did not find a gender difference, but included a very small sample size [39].

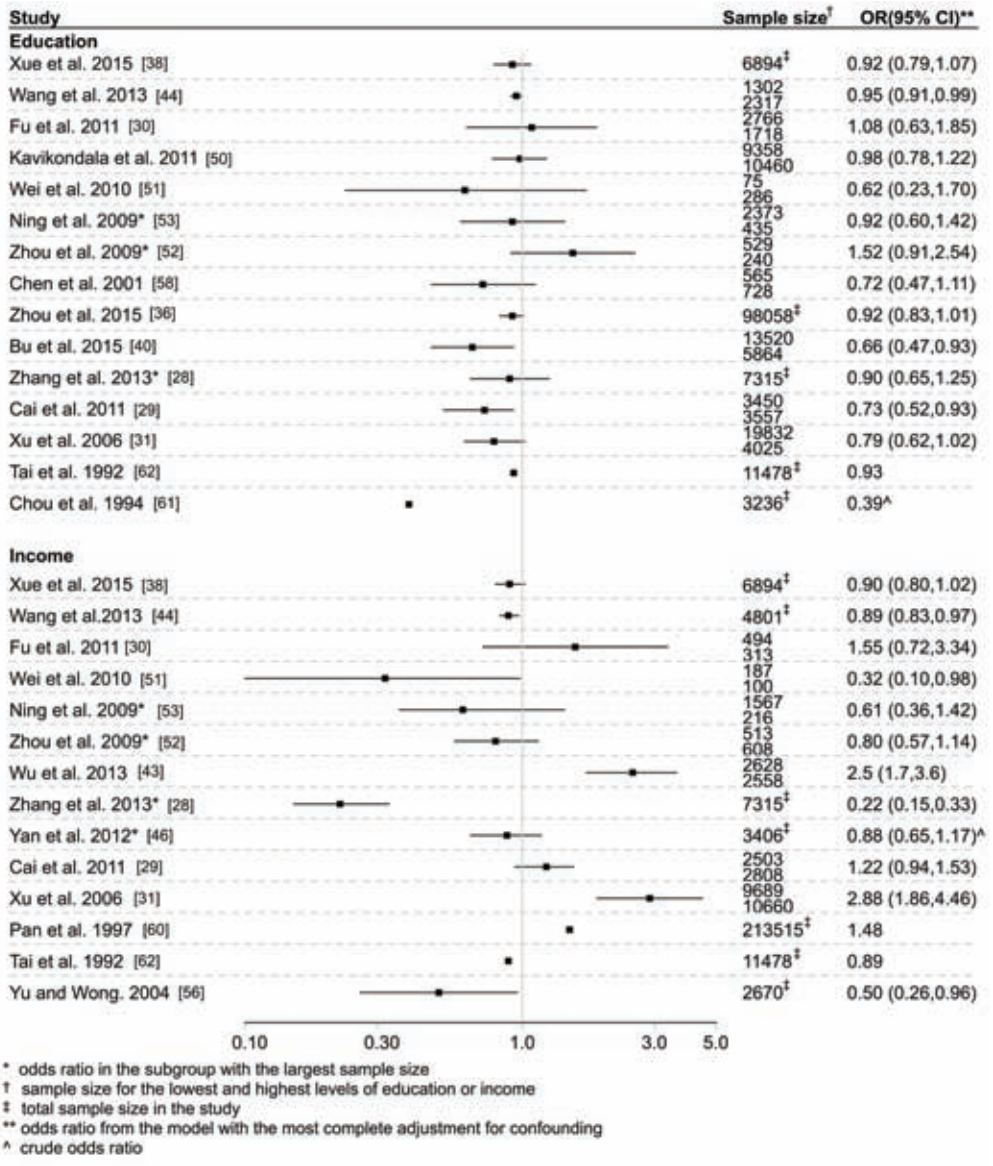

Figure 3. Study specific odds ratios for type 2 diabetes comparing the highest vs lowest levels of education and income in included studies.

Of the 12 studies reporting on occupation and type 2 diabetes, eight reported prevalence estimates, with two reporting estimates standardized for various factors. Nine studies reported odds ratios, all of which controlled for various potential confounders. As the measures of occupation were heterogeneous, it is not easy to rank the occupation classification from high to low SES. This affects the comparability of the findings from studies reporting on occupation and type 2 diabetes and we were unable to present the results using a figure as for education and income. Zhou et al. [36] and Zhang et al. [28] found an increased risk of type 2 diabetes in retired compared to employed people after adjusting for age. Xu et al. [31] found the prevalence of type 2 diabetes was much higher in people with white collar occupations than blue collar occupations, even after controlling for confounding factors. Chen and Chen [47] found professionals had the lowest risk of type 2 diabetes compared to other kinds of occupation such as officials, salespersons and assemblers. However, most studies did not report a statistically significant association between occupation and prevalence of type 2 diabetes (Appendices S10, S11 and S12 in **Online Supplementary Document**).

DISCUSSION

This systematic review of the association between SES and prevalence of type 2 diabetes in Chinese populations in mainland China, Hong Kong and Taiwan suggests that higher education is probably associated with a decreased prevalence of type 2 diabetes. The association between income and type 2 diabetes was inconsistent between studies. While most studies found no association between occupation and diabetes prevalence, a few did report higher prevalence among people who were retired or in white–collar jobs compared to other occupations. These findings were not obviously influenced by study year or quality score.

Explanation for findings in this systematic review

In this systematic review, most studies suggested that higher levels of education are associated with decreased prevalence of diabetes, but some found the opposite association. For example, Xu et al. [39] reported a positive association between education and prevalence of type 2 diabetes in a relatively small Tibetan population. Tibet is an undeveloped region at an earlier economic development stage compared with other parts of China, which may partly contribute to this different result. Despite being conducted in the same area and using the same methods Liu et al. [35] found a much higher prevalence of type 2 diabetes in higher education groups in people aged 60 years or older in a 2010 survey, having found no association in the 2001 survey. This study dichotomised education using a cut–off of 7 years. However, from the 1960s a large proportion of Chinese started to receive middle school education (9 years of education) [64] and so choosing 7 years as the cut–point may have different effects in different birth cohorts. Xu et al. [31] found a significantly higher crude prevalence of type 2 diabetes in people with a higher education level, but the logistic regression model revealed a non–significant inverse association after adjusting for several variables. This means that the crude positive association between prevalence of type 2 diabetes and education may have been distorted by confounding factors. Furthermore, differences in definitions of education might explain some of the heterogeneity observed between studies. It is important to note that all three studies reporting a positive association between education and prevalence of type 2 diabetes measured education as school years completed [31,35,39]. However, people may receive different economic return from school years completed compared to educational level achieved [65].

The direction of association between income and prevalence of type 2 diabetes differed between studies in our review. This is inconsistent with previous studies which has found people from high–income countries with low income were more likely to have type 2 diabetes [66,67], but an opposite association in people from low– and middle–income countries [22,68]. There are several potential explanations for the inconsistent association between income and diabetes in our review. First, unlike education, which is usually completed in young adulthood, income is unstable and sensitive to change in life circumstances and so it is not necessarily a good indicator of whole life SES [69]. Second, self–reported income is more likely to be under– or over–estimated in studies as people may consider income sensitive information and be reluctant to report it, which obviously decreases the reliability and increases the risk of non–differential bias toward a null association [70]. In addition, income is only one part of an individual's assets and is not a very good measure among older people, especially retired people, where income is low but actual wealth can be high. Furthermore, the classification of income level is very different between studies with the lowest category ranging from <2500¥ (US$ 360) to <10 000¥ (US$ 1440) for a family's whole year income [41,52]. Four studies in this systematic review used personal income as individual's measure of SES [28,53,54,60]. However, total family income is believed to be more reliable than personal income, especially for young adults and women, who may not be the main earners in the family [69]. However, when applying total family income to all family members, family size should be accounted for, since for the same income, a larger family may have higher outgoing costs than a smaller family [71]. Among 15 studies reporting total family income, only one study considered family size [31]. Furthermore, China has undergone a very rapid economic development during the past several decades [72]. However, changes in an individual's lifestyle and health–related behaviors may lag behind changes in economic conditions and may also differ in different settings.

We did not find a consistent association between occupation and prevalence of type 2 diabetes in this systematic review, though a few studies reported statistically significant findings. The classification of occupation across studies was complex and heterogeneous. Occupation in China is associated with education and income but also differing levels of physical activity that makes its classification as a risk factor for diabetes challenging.

The methods used to diagnose type 2 diabetes varied across studies, which was another source of heterogeneity between studies. Different diagnostic criteria may have a different effect on the magnitude of the association between SES and diabetes. According to the latest China nationally representative diabetes

survey, around 70% of Chinese adults with diabetes were undiagnosed [3]. Thus, among the five studies that defined diabetes based on self–report, a large proportion of those with diabetes in these studies may have been erroneously assigned to the non–diabetic group and this misclassification may differ by SES groups. Bragg et al. [41] found that undiagnosed diabetes was more common among people in low education and low income groups, while the opposite was found for self–reported diabetes. People with high SES typically have more access to health resources such as routine health checks, thus they may be more likely to be aware of their health conditions. However, another study [28] did not find this difference. To more clearly examine this association, more studies reporting on the association between SES and both diagnosed and undiagnosed diabetes are required.

Limitations of the study

Our review was limited to papers published in the English language. A systematic review of studies published in Chinese is also needed to exclude potential bias. Another important limitation is that the association between SES and diabetes was rarely the main research aim or hypothesis of most identified studies. SES was generally considered as a descriptive variable of the study sample or a potential confounder of relationships between other variables and health outcomes. It is also important to note that most prevalence estimates presented in studies were unadjusted for age, which is a key confounder of the association between SES and diabetes. Additionally, all but three studies reporting odds ratios were adjusted for various factors in addition to age and sex, many of which may lie on the causal pathway between SES and type 2 diabetes. Inclusion of these factors may have led to over–adjustment of the association between SES indicators and type 2 diabetes. A few studies in this systematic review found that the strength and direction of association between SES and prevalence of type 2 diabetes differed by sex but it is not clear whether this is consistent in different populations. A sex–specific SES gradient in health outcomes has been reported by previous studies [73]. For example, the SES gradient in prevalence of type 2 diabetes appears to be stronger in women than men in Scotland [74]. Furthermore, the scope of this review did not include the association between other indicators of individual SES (such as wealth, house condition, car and home ownership) or area–based SES measures [75].

SES indicators may have different values and implications in different urban and rural settings and in developed and undeveloped areas [76–79]. For example, people in rural areas may not need a very high education level to engage in agricultural or farming work. Also, the same level of income may have different implications for people living in developed and undeveloped areas. For example, an average monthly income of US$ 1500 provides vastly different standards of living for a family in west China compared to those living in Hong Kong. In this review, efforts were made to examine whether the association between SES and type 2 diabetes vary by study location in urban, rural mainland China, Hong Kong and Taiwan. However, the inconsistent findings and limited number of studies within each of these study geographical locations meant that no obvious patterns were observed.

Implications for health policy and future research

Health polices for reducing socioeconomic health disparities in diabetes can only be made when the association between SES and diabetes is fully understood. This review found some evidence of an inverse relationship between education and prevalence of type 2 diabetes in Chinese populations. However, associations between income, occupation and diabetes were inconsistent. More studies, including review of those in Chinese language publications, are needed to explore the association between income and occupation and diabetes and to identify whether associations differ in different sub–groups of the population and in different regions of China. Additionally, repeated cross–sectional studies are needed to explore how associations between SES and diabetes change over time in China.

Although the association between SES and diabetes varies between countries, China is the country with the largest number of people with diabetes in the world and is undergoing rapid economic development. The epidemiological transition in China and the challenges of identifying and addressing socio–economic inequalities in health therefore have important implications for global health.

CONCLUSIONS

This first systematic review of the association between individual SES and prevalence of type 2 diabetes in China found that low education is probably associated with an increased prevalence of type 2 diabetes. However, further work is needed to determine whether similar associations are observed with income and occupation.

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REFERENCES

1 NCD Risk Factor Collaboration. Worldwide trends in diabetes since 1980: a pooled analysis of 751 population-based studies with 4.4 million participants. Lancet. 2016;387:1513-30. Medline:27061677 doi:10.1016/S0140-6736(16)00618-8

2 National Diabetes Co-operative Study Group. A mass survey of diabetes mellitus in a population of 300 000 in 14 provinces and municipalities in China. [article in Chinese]. Zhonghua Nei Ke Za Zhi. 1981;20:678-83. Medline:7341098

3 Xu Y, Wang L, He J, Bi Y, Li M, Wang T, et al. Prevalence and control of diabetes in Chinese adults. JAMA. 2013;310:948-59. Medline:24002281 doi:10.1001/jama.2013.168118

4 International Diabetes Federation. IDF diabetes atlas seventh edition. 2015. Available: http://www.diabetesatlas.org/resources/2015-atlas.html. Accessed: 11 May 2017.

5 Lynch J, Kaplan G. Socioeconomic position. 2000: Social epidemiology. New York: Oxford University Press.

6 Cutler DM, Lleras-Muney A, Vogl T. Socioeconomic status and health: dimensions and mechanisms. Cambridge, MA: National Bureau of Economic Research; 2008.

7 Grotto I, Huerta M, Sharabi Y. Hypertension and socioeconomic status. Curr Opin Cardiol. 2008;23:335-9. Medline:18520717 doi:10.1097/HCO.0b013e3283021c70

8 McLaren L. Socioeconomic status and obesity. Epidemiol Rev. 2007;29:29-48. Medline:17478442 doi:10.1093/epirev/mxm001

9 Clark AM, DesMeules M, Luo W, Duncan AS, Wielgosz A. Socioeconomic status and cardiovascular disease: risks and implications for care. Nat Rev Cardiol. 2009;6:712-22. Medline:19770848 doi:10.1038/nrcardio.2009.163

10 Agardh EE, Ahlbom A, Andersson T, Efendic S, Grill V, Hallqvist J, et al. Explanations of socioeconomic differences in excess risk of type 2 diabetes in Swedish men and women. Diabetes Care. 2004;27:716-21. Medline:14988291 doi:10.2337/diacare.27.3.716

11 Cella DF, Orav EJ, Kornblith AB, Holland JC, Silberfarb PM, Lee KW, et al. Socioeconomic status and cancer survival. J Clin Oncol. 1991;9:1500-9. Medline:2072149 doi:10.1200/JCO.1991.9.8.1500

12 Marmot M. Social determinants of health inequalities. Lancet. 2005;365:1099-104. Medline:15781105 doi:10.1016/S0140-6736(05)74234-3

13 Hossain P, Kawar B, El Nahas M. Obesity and diabetes in the developing world—a growing challenge. N Engl J Med. 2007;356:213-5. Medline:17229948 doi:10.1056/NEJMp068177

14 Jeon CY, Lokken RP, Hu FB, van Dam RM. Physical activity of moderate intensity and risk of type 2 diabetes a systematic review. Diabetes Care. 2007;30:744-52. Medline:17327354 doi:10.2337/dc06-1842

15 Agardh E, Allebeck P, Hallqvist J, Moradi T, Sidorchuk A. Type 2 diabetes incidence and socio-economic position: a systematic review and meta-analysis. Int J Epidemiol. 2011;40:804-18. Medline:21335614 doi:10.1093/ije/dyr029

16 Connolly V, Unwin N, Sherriff P, Bilous R, Kelly W. Diabetes prevalence and socioeconomic status: a population based study showing increased prevalence of type 2 diabetes mellitus in deprived areas. J Epidemiol Community Health. 2000;54:173-7. Medline:10746110 doi:10.1136/jech.54.3.173

17 Espelt A, Borrell C, Roskam AJ, Rodríguez-Sanz M, Stirbu I, Dalmau-Bueno A, et al. Socioeconomic inequalities in diabetes mellitus across Europe at the beginning of the 21st century. Diabetologia. 2008;51:1971-9. Medline:18779946 doi:10.1007/s00125-008-1146-1

18 Evans JM, Newton RW, Ruta DA, MacDonald TM, Morris AD. Socio-economic status, obesity and prevalence of Type 1 and Type 2 diabetes mellitus. Diabet Med. 2000;17:478-80. Medline:10975218 doi:10.1046/j.1464-5491.2000.00309.x

19 Meadows P. Variation of diabetes mellitus prevalence in general practice and its relation to deprivation. Diabet Med. 2000;17:478-80. Medline:10975218

20 Robbins JM, Vaccarino V, Zhang H, Kasl SV. Socioeconomic status and type 2 diabetes in African American and non-Hispanic white women and men: evidence from the Third National Health and Nutrition Examination Survey. Am J Public Health. 2001;91:76-83. Medline:11189829 doi:10.2105/AJPH.91.1.76

21 Tang M, Chen Y, Krewski D. Gender-related differences in the association between socioeconomic status and self-reported diabetes. Int J Epidemiol. 2003;32:381-5. Medline:12777423 doi:10.1093/ije/dyg075

22 abu Sayeed M, Ali L, Hussain MZ, Rumi MA, Banu A, Azad Khan AK. Effect of socioeconomic risk factors on the difference in prevalence of diabetes between rural and urban populations in Bangladesh. Diabetes Care. 1997;20:551-5. Medline:9096979 doi:10.2337/diacare.20.4.551

23 Ali O, Tan TT, Sakinah O, Khalid BA, Wu LL, Ng ML. Prevalence of NIDDM and impaired glucose tolerance in aborigines and Malays in Malaysia and their relationship to sociodemographic, health, and nutritional factors. Diabetes Care. 1993;16:68-75. Medline:8422835 doi:10.2337/diacare.16.1.68

24 Illangasekera U, Rambodagalla S, Tennakoon S. Temporal trends in the prevalence of diabetes mellitus in a rural community in Sri Lanka. J R Soc Promot Health. 2004;124:92-4. Medline:15067982 doi:10.1177/146642400412400214

25 Ramachandran A, Snehalatha C, Kapur A, Vijay V, Mohan V, Das AK, et al. High prevalence of diabetes and impaired glucose tolerance in India: National Urban Diabetes Survey. Diabetologia. 2001;44:1094-101. Medline:11596662 doi:10.1007/s001250100627

26 World Health Organization. Noncommunicable disease risk factors and socioeconomic inequalities – what are the links? A multicountry analysis of noncommunicable disease surveillance data. 2010. Available: http://www.wpro.who.int/publications/PUB_9789290614746/en/. Accessed: 1 February 2017.

27 Xie Y, Zhou X. Income inequality in today's China. Proc Natl Acad Sci U S A. 2014;111:6928-33. Medline:24778237 doi:10.1073/pnas.1403158111

28 Zhang H, Xu W, Dahl AK, Xu Z, Wang HX, Qi X. Relation of socio-economic status to impaired fasting glucose and Type 2 diabetes: findings based on a large population-based cross-sectional study in Tianjin, China. Diabet Med. 2013;30:e157-62. Medline:23397898 doi:10.1111/dme.12156

29 Le C, Jun D, Zhankun S, Yichun L, Jie T. Socioeconomic differences in diabetes prevalence, awareness, and treatment in rural southwest China. Trop Med Int Health. 2011;16:1070-6. Medline:21668591 doi:10.1111/j.1365-3156.2011.02805.x

30 Fu C, Chen Y, Wang F, Wang X, Song J, Jiang Q. High prevalence of hyperglycaemia and the impact of high household income in transforming rural China. BMC Public Health. 2011;11:862. Medline:22078718 doi:10.1186/1471-2458-11-862

31 Xu F, Yin XM, Zhang M, Leslie E, Ware R, Owen N. Family average income and diagnosed type 2 diabetes in urban and rural residents in regional mainland China. Diabet Med. 2006;23:1239-46. Medline:17054602 doi:10.1111/j.1464-5491.2006.01965.x

32 Leung GM, Lu J-FR, Meng Q. Mainland China, Hong Kong, and Taiwan, Health Systems of. In International Encyclopedia of Public Health. 2nd edition. Oxford: Academic Press; 2017.

33 Wells G, Shea B, O'Connell D, Peterson J, Welch V, Tugwell P. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. 2000. Available: http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp. Accessed: 23 June 2016.

34 Wu J, Cheng X, Qiu L, Xu T, Zhu G, Han J, et al. Prevalence and clustering of major cardiovascular risk factors in China: a recent cross-sectional survey. Medicine. 2016;95:e2712. Medline:26962771 doi:10.1097/MD.0000000000002712

35 Liu M, Wang J, He Y, Jiang B, Wu L, Wang Y, et al. Awareness, treatment and control of type 2 diabetes among Chinese elderly and its changing trend for past decade. BMC Public Health. 2016;16:278. Medline:26987372 doi:10.1186/s12889-016-2874-7

36 Zhou M, Astell-Burt T, Bi Y, Feng X, Jiang Y, Li Y, et al. Geographical variation in diabetes prevalence and detection in china: multilevel spatial analysis of 98,058 adults. Diabetes Care. 2015;38:72-81. Medline:25352654 doi:10.2337/dc14-1100

37 Yu J, Ma Y, Yang S, Pang K, Yu Y, Tao Y, et al. Risk factors for cardiovascular disease and their clustering among adults in Jilin (China). Int J Environ Res Public Health. 2015;13:ijerph13010070.

38 Xue B, Tan JB, Ning F, Sun JP, Zhang KY, Liu L, et al. Association between serum uric acid and prevalence of type 2 diabetes diagnosed using HbA1c criteria among Chinese Adults in Qingdao, China. Biomed Environ Sci. 2015;28:884-93. Medline:26777908

39 Xu S, Jiayong Z, Li B, Zhu H, Chang H, Shi W, et al. Prevalence and clustering of cardiovascular disease risk factors among Tibetan adults in China: a population-based study. PLoS One. 2015;10:e0129966. Medline:26047133 doi:10.1371/journal.pone.0129966

40 Bu S, Ruan D, Yang Z, Xing X, Zhao W, Wang N, et al. Sex-specific prevalence of diabetes and cardiovascular risk factors in the middle-aged population of China: a subgroup analysis of the 2007-2008 China National Diabetes and Metabolic Disorders Study. PLoS One. 2015;10:e0139039. Medline:26406982 doi:10.1371/journal.pone.0139039

41 Bragg F, Li L, Smith M, Guo Y, Chen Y, Millwood I, et al. Associations of blood glucose and prevalent diabetes with risk of cardiovascular disease in 500 000 adult Chinese: the China Kadoorie Biobank. Diabet Med. 2014;31:540-51. Medline:24344928 doi:10.1111/dme.12392

42 Xia Z, Wang Z, Cai Q, Yang J, Zhang X, Yang T. Prevalence and risk factors of type 2 diabetes in the adults in Haikou City, Hainan Island, China. Iran J Public Health. 2013;42:222-30. Medline:23641399

43 Wu F, Guo Y, Kowal P, Jiang Y, Yu M, Li X, et al. Prevalence of major chronic conditions among older Chinese adults: the Study on Global AGEing and Adult Health (SAGE) Wave 1. PLoS One. 2013;8:e74176. Medline:24069278 doi:10.1371/journal.pone.0074176

44 Wang KW, Shu ZK, Cai L, Wu JQ, Wei W. Assessment of the magnitude of contextual and individual demographic effects on diabetes mellitus and glucose intolerance in rural southwest China: a multilevel analysis. PLoS One. 2013;8:e68553. Medline:23874667 doi:10.1371/journal.pone.0068553

45 Le C, Lin L, Jun D, Jianhui H, Keying Z, Wenlong C, et al. The economic burden of type 2 diabetes mellitus in rural southwest China. Int J Cardiol. 2013;165:273-7. Medline:21908062 doi:10.1016/j.ijcard.2011.08.039

46 Yan S, Li J, Li S, Zhang B, Du S, Gordon-Larsen P, et al. The expanding burden of cardiometabolic risk in China: The China Health and Nutrition Survey. Obes Rev. 2012;13:810-21. Medline:22738663 doi:10.1111/j.1467-789X.2012.01016.x

47 Chen FL, Chen PY. Health disparities among occupations in Taiwan: a population study. J Occup Health. 2012;54:147-53. Medline:22322107 doi:10.1539/joh.11-0052-FS

48 Shi Z, Yuan B, Zhang C, Zhou M, Holmboe-Ottesen G. Egg consumption and the risk of diabetes in adults, Jiangsu, China. Nutrition. 2011;27:194-8. Medline:20471806 doi:10.1016/j.nut.2010.01.012

49 Lin WY, Xaiver Pi-Sunyer F, Chen CC, Davidson LE, Liu CS, Li TC, et al. Coffee consumption is inversely associated with type 2 diabetes in Chinese. Eur J Clin Invest. 2011;41:659-66. Medline:21226707 doi:10.1111/j.1365-2362.2010.02455.x

50 Kavikondala S, Jiang CQ, Zhang WS, Cheng KK, Lam TH, Leung GM, et al. Intergenerational influences on diabetes in a developing population: the Guangzhou Biobank Cohort Study. Am J Hum Biol. 2011;23:747-54. Medline:21987430 doi:10.1002/ajhb.21206

51 Wei W, Liu SY, Zeng FF, Yao SP, Zhang HT, Wan G, et al. Type 2 diabetes and impaired glucose tolerance in North-China-based rural community adults. Public Health. 2010;124:593-601. Medline:20846702 doi:10.1016/j.puhe.2010.05.014

52 Zhou X, Ji L, Luo Y, Han X, Zhang X, Sun X, et al. Risk factors associated with the presence of diabetes in Chinese communities in Beijing. Diabetes Res Clin Pract. 2009;86:233-8. Medline:19836096 doi:10.1016/j.diabres.2009.09.014

53 Ning F, Pang ZC, Dong YH, Gao WG, Nan HR, Wang SJ, et al. Risk factors associated with the dramatic increase in the prevalence of diabetes in the adult Chinese population in Qingdao, China. Diabet Med. 2009;26:855-63. Medline:19719705 doi:10.1111/j.1464-5491.2009.02791.x

54 Hu D, Sun L, Fu P, Xie J, Lu J, Zhou J, et al. Prevalence and risk factors for type 2 diabetes mellitus in the Chinese adult population: the InterASIA Study. Diabetes Res Clin Pract. 2009;84:288-95. Medline:19442859 doi:10.1016/j.diabres.2009.02.021

55 Chou KL, Chi I. Functional disability related to diabetes mellitus in older Hong Kong Chinese adults. Gerontology. 2005;51:334-9. Medline:16110236 doi:10.1159/000086371

56 Yu TS, Wong TW. Socioeconomic distribution of health and health care utilization in a new town in Hong Kong, China. Biomed Environ Sci. 2004;17:234-45. Medline:15386950

57 Woo J, Ho SC, Sham A, Sea MM, Lam KS, Lam TH, et al. Diet and glucose tolerance in a Chinese population. Eur J Clin Nutr. 2003;57:523-30. Medline:12700613 doi:10.1038/sj.ejcn.1601586

58 Chen KT, Chen CJ, Gregg EW, Engelgau MM, Narayan KM. Prevalence of type 2 diabetes mellitus in Taiwan: Ethnic variation and risk factors. Diabetes Res Clin Pract. 2001;51:59-66. Medline:11137183 doi:10.1016/S0168-8227(00)00200-X

59 Chen KT, Chen CJ, Gregg EW, Williamson DF, Narayan KM. High prevalence of impaired fasting glucose and type 2 diabetes mellitus in Penghu Islets, Taiwan: evidence of a rapidly emerging epidemic? Diabetes Res Clin Pract. 1999;44:59-69. Medline:10414941 doi:10.1016/S0168-8227(99)00025-X

60 Pan XR, Yang WY, Li GW, Liu J. Prevalence of diabetes and its risk factors in China, 1994. Diabetes Care. 1997;20:1664-9. Medline:9353605 doi:10.2337/diacare.20.11.1664

61 Chou P, Liao MJ, Tsai ST. Associated risk factors of diabetes in Kin-Hu, Kinmen. Diabetes Res Clin Pract. 1994;26:229-35. Medline:7736904 doi:10.1016/0168-8227(94)90065-5

62 Tai TY, Chuang LM, Wu HP, Chen CJ. Association of body build with non-insulin-dependent diabetes mellitus and hypertension among Chinese adults: a 4-year follow-up study. Int J Epidemiol. 1992;21:511-7. Medline:1634313 doi:10.1093/ije/21.3.511

63 Woo J, Ho SC, Lau S, Lau J, Yuen YK. Prevalence of cognitive impairment and associated factors among elderly Hong Kong Chinese aged 70 years and over. Neuroepidemiology. 1994;13:50-8. Medline:8190206 doi:10.1159/000110358

64 Saywell WG. Education in China since Mao. Can J High Educ. 1980;10:1-27.

65 Faia MA. Selection by certification: a neglected variable in stratification research. Am J Sociol. 1981;86:1093-111. doi:10.1086/227355

66 Wallach JB, Rey MJ. A socioeconomic analysis of obesity and diabetes in New York City. Prev Chronic Dis. 2009;6:A108. Medline:19527580

67 Dinca-Panaitescu S, Dinca-Panaitescu M, Bryant T, Daiski I, Pilkington B, Raphael D. Diabetes prevalence and income: results of the Canadian Community Health Survey. Health Policy. 2011;99:116-23. Medline:20724018 doi:10.1016/j.healthpol.2010.07.018

68 Ramachandran A, Mary S, Yamuna A, Murugesan N, Snehalatha C. High prevalence of diabetes and cardiovascular risk factors associated with urbanization in India. Diabetes Care. 2008;31:893-8. Medline:18310309 doi:10.2337/dc07-1207

69 Galobardes B, Shaw M, Lawlor DA, Lynch JW, Davey Smith G. Indicators of socioeconomic position (part 1). J Epidemiol Community Health. 2006;60:7-12. Medline:16361448 doi:10.1136/jech.2004.023531

70 Turrell G. Income non-reporting: implications for health inequalities research. J Epidemiol Community Health. 2000;54:207-14. Medline:10746115 doi:10.1136/jech.54.3.207

71 Krieger N, Williams DR, Moss NE. Measuring social class in US public health research: concepts, methodologies, and guidelines. Annu Rev Public Health. 1997;18:341-78. Medline:9143723 doi:10.1146/annurev.publhealth.18.1.341

72 The World Bank. Poverty & Equity, China. 2016. Available: http://povertydata.worldbank.org/poverty/country/CHN. Accessed: 29 August 2016.

73 Phillips SP, Hamberg K. Women's relative immunity to the socio-economic health gradient: artifact or real? Glob Health Action. 2015;8:27259. doi:10.3402/gha.v8.27259

74 Walker JJ, Livingstone SJ, Colhoun HM, Lindsay RS, McKnight JA, Morris AD, et al. Effect of socioeconomic status on mortality among people With Type 2 Diabetes A study from the Scottish Diabetes Research Network Epidemiology Group. Diabetes Care. 2011;34:1127-32. Medline:21421800 doi:10.2337/dc10-1862

75 Liberatos P, Link BG, Kelsey JL. The measurement of social class in epidemiology. Epidemiol Rev. 1988;10:87-121. Medline:3066632 doi:10.1093/oxfordjournals.epirev.a036030

REFERENCES

76 Haynes R, Gale S. Deprivation and poor health in rural areas: inequalities hidden by averages. Health Place. 2000;6:275-85. Medline:11027953 doi:10.1016/S1353-8292(00)00009-5

77 Barnett S, Roderick P, Martin D, Diamond I, Wrigley H. Interrelations between three proxies of health care need at the small area level: an urban/rural comparison. J Epidemiol Community Health. 2002;56:754-61. Medline:12239201 doi:10.1136/jech.56.10.754

78 Gilthorpe MS, Wilson RC. Rural/urban differences in the association between deprivation and healthcare utilisation. Soc Sci Med. 2003;57:2055-63. Medline:14512237 doi:10.1016/S0277-9536(03)00071-6

79 Martin D, Brigham P, Roderick P, Barnett S, Diamond I. The (mis) representation of rural deprivation. Environ Plann A. 2000;32:735-51. doi:10.1068/a32130

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