



Conference on ‘Nutrition dynamics in Africa: opportunities and challenges for meeting the sustainable development goals’

Effective nutrition education and communication for sustainable maternal and child health

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Maternal and child health (MCH) consists of an interdependent reproductive system that collectively determines the survival of the mother during childbirth, and determines the health and survival of the child. This interdependency underscores the importance of appropriate and timely interventions during pregnancy through the first 1000 d at the minimum. The Millennium Development Goals (MDG) recommended the use of the continuum of care for the development of interventions by addressing all the stages of MCH. The purpose of the present paper is to review the factors that contributed to the attainment of the MDG 4 and MDG 5 by analysing the interventions conducted by the countries that achieved at least 5.0 and 5.5 %, respectively, and determine the level of their intervention based on the MCH conceptual framework. Out of the eighteen selected countries discussed, fifteen countries achieved their target for either MDG 4 or MDG 5 or both, while three countries did not achieve their target. The countries that were more likely to achieve their targets addressed the societal, underlying and direct causes, and implemented country wide policies. In contrast, the countries that did not succeed were more likely to address the direct causes with poor policy implementation. Understanding the motivation and limitations of the target population, including nutrition education and targeting behaviour change has the potential to result in sustainable MCH. This information has the potential to enlighten the policymakers as we progress to the sustainable development goals, specifically goals 2 and 3.

Nutrition education: Maternal and child health: Effective interventions

Maternal and child health

Maternal and child health (MCH) refers to the life course involving women before and during pregnancy up to immediately after childbirth and children to their fifth birthday⁽¹⁾. According to the Save the Children’s 16th annual Mothers’ index that assessed the wellbeing of mothers and children in 179 countries, the eleven countries that performed poorly in all indicators were all from developing countries in Africa, except for Haiti. On average one in every thirty women dies from pregnancy-related causes and one in every eight children dies before their fifth birthday⁽²⁾.

The reproductive system consists of interdependent and critical stages that collectively determine the survival of the mother during childbirth, the pregnancy outcome

and the health of the newborn child for the first 1000 d⁽³⁾. This interdependency underscores the importance of appropriate and timely interventions during pregnancy, even starting pre-conception, if possible and systematically continue through pregnancy, childbirth and neonatal to 1000 d at the minimum^(4,5).

Maternal health

The nutritional status of women at the time of conception and during pregnancy are major determinants of the pregnancy outcome as evidenced by the health, growth and development of the fetus and the newborn^(5,6). For example, evidence indicates that placental and fetal development is most vulnerable during the

Abbreviations: ANV, antenatal care; MCH, maternal and child health; MDG, Millennium Development Goals.

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period of rapid placental development during the first trimester⁽³⁾. Neural tube defects, cretinism, intrauterine growth restriction and preterm birth are well-known adverse outcomes of general and specific nutrient deficiencies, such as folate, iodine, iron, calcium, magnesium, phosphorous, potassium, sodium, sulphur, zinc, vitamins B₁, B₂, B₃, B₅ and D, that are related to maternal nutritional status during and before conception, thus underscoring the importance of pre-conception care⁽⁷⁾. In addition to mother's survival, undernourished women give birth to smaller infants than well-nourished mothers, an independent risk factor for the survival of the newborn⁽⁸⁾. Low-birth weight infants, in turn, are at a higher risk of death due to infections and asphyxia⁽³⁾.

In addition to compromised pregnancy outcomes, maternal malnutrition and associated poor health are the direct causes of maternal morbidity and mortality as a result of haemorrhage, infection, high blood pressure and obstructed labour⁽¹⁾. For example, calcium deficiency is a risk factor for hypertensive disorders of pregnancy such as pre-eclampsia, while iron deficiency anaemia may increase the risk of maternal mortality during childbirth⁽⁷⁾. Results from two different meta-analyses proved the efficacy of calcium supplementation for reducing gestational hypertensive disorders in pregnant women at high risk of developing hypertension or with low calcium intakes^(9,10). The first meta-analysis showed that calcium supplementation during pregnancy significantly reduced the risk of preeclampsia by 52 %, severe pre-eclampsia by 25 %, incidence of severe pre-eclampsia by 24 % and low birth weight by 15 % in women with high risk of developing hypertension during pregnancy⁽⁹⁾. The second meta-analysis found that there was a 35 % reduction in the risk of gestational hypertension in women at high risk, and those with low calcium intake and a reduction by 20 % in maternal death or severe morbidity for women that received calcium supplementation⁽¹⁰⁾. Evidence indicates that maternal survival is determined by the women's nutritional status. Specifically, maternal short stature and undernutrition are indicators of poor nutritional status during childhood; while iron deficiency is associated with a higher risk of death of the mother at delivery and accounts for at least 20 % of maternal deaths⁽⁶⁾. For example, a study from Nepal found that a low mid-upper arm circumference in early to mid-gestation was associated with risk of maternal death during pregnancy⁽¹¹⁾. Similarly, a study conducted by Merchant, Villar and Kestler identified that maternal short stature increases risk of dystocia (difficult labour), as measured by cephalopelvic disproportion or assisted caesarean deliveries⁽¹²⁾. Also, a meta-analysis carried out by Kozuki *et al.* in short maternal stature proved that short stature was significantly associated with short-gestational-age, preterm appropriate-for-gestational-age and preterm short-gestational age in low and middle income countries⁽¹³⁾.

Neonatal and child health

The Millennium Development Goals (MDG) Report in 2015 showed that for the MDG 4, the number of deaths

of children under 5 has declined from 12.7 million in 1990 to almost 6 million in 2015 globally⁽¹⁴⁾. However, the probability of a newborn dying during the first 28 d of life is still high compared with the mortality rate for children between age 1 month and 5 years; 45 % of total deaths in 2015, 5 % more than in 2000⁽¹⁵⁾. Nearly 4 million newborns die (40 % of under 5 deaths) within 28 d of birth⁽¹⁶⁾.

For the children that survive the first 28 d, being able to survive and thrive the first 1000 d requires a concerted effort of a healthy mother, exclusive breastfeeding, a sanitary environment, appropriate complementary food at 6 months and access to preventive healthcare at minimum⁽²⁾. Although exclusive breastfeeding has proved to save babies from dying of infections, it does not prevent stunting among low-income, overworked and malnourished mothers who might not be able to produce sufficient milk to meet the needs of a 2–6 months old baby. Malnutrition as evidenced by the high rates of stunting, wasting and micronutrient deficiencies is a major threat to MCH, accounting for 35 % of the disease burden in children under 5. This translates into 3.5 million maternal and child deaths for which the underlying cause is undernutrition⁽¹⁷⁾. These findings imply that more dietary assistance is needed for low-income mothers over and above the recommendation to exclusively breastfeed their children. In addition to lack of proper nourishment, impoverished mothers may not have access to clean water or environment and a diverse diet, making it easy for the opportunistic diseases like infections claiming the lives or compromising children's nutritional status⁽¹⁸⁾.

According to the MDG assessment report, the global under-5 mortality rate has significantly dropped by more than half, from ninety to forty-three deaths per 1000 live births between 1990 and 2015^(2,14). Despite this great achievement, it is noteworthy that about 16 000 children under 5 continue to die every day, and an estimated 5.9 million children die before their fifth birthday and almost half of those deaths take place within the first month of life⁽¹⁵⁾. Evidence indicates that preventable causes such as pneumonia, diarrhoea and malaria accounted for 43 % of the under-5 deaths according to the UNICEF 2015 report⁽¹⁵⁾. Lack of access to effective care and resources at the community level is therefore the underlying cause of these deaths. For example, antibiotics for pneumonia are available to only about 31 % of affected children, and diarrhoea treatment only to 35 %⁽¹⁹⁾. Specifically, for the prevention of pneumonia the Hib vaccine is widely used around the globe except in China and Thailand where they only have access to this vaccine in the private market. According to the Pneumonia & Diarrhoea Progress Report there are still some countries that have an extremely low coverage of this vaccine, including India (20 %), Indonesia (21 %), Somalia (42 %) and Chad (46 %)⁽²⁰⁾. It is therefore clear that the global advance in child survival has failed to protect many of the world's youngest children from vulnerable situations. If the present trend continues, it will take 10 or more years to reach the global target⁽¹⁵⁾.

Continuum of care

To address these complex and multilevel issues, the Global Business Plan for MDG 4 and 5 recommends use of the continuum of care⁽²¹⁾. Understanding that the health of the mother and child are interrelated, and that the nutritional and health status of the mother affects the health of the child, the goal of the continuum of care is to provide comprehensive seamless and integrated health services for women and their children throughout the life cycle, starting from pre-pregnancy through delivery and the immediate postnatal period to the child's fifth birthday (Fig. 1)^(22–24).

Similarly, the interventions and delivery of care should be interrelated and mutually supportive and available in all the places that the mothers and children live, play and work starting from the household, community and outpatient or healthcare centres based on the complexity of the care needed⁽¹⁶⁾. This approach is cost and time effective, especially in low-income countries where continuum of care is more critical than specialised care; however, it will require more comprehensive training for the healthcare providers with competences ranging from preconception to childhood nutrition and health needs⁽²⁵⁾.

Evidence indicates that there is a shortage of health workforce in low-income countries⁽²⁶⁾, but a more critical question is whether the healthcare providers are receiving adequate training and competences to deliver an integrated service from pre-pregnancy to childhood. A review conducted by Jongh *et al.*⁽²⁷⁾ identified lack of training as a barrier to delivering an integrated tuberculosis, prevention of mother-to-child transmission and antenatal care (ANC) programme in South Africa, where not all healthcare workers were trained in all care aspects, contributing to poor tuberculosis case identification among pregnant women. The complexity of the continuum of care and the differences in economic, social, political and cultural backgrounds in each country complicates specifying the competences needed to deliver integrated care. An important first step is to ensure competent healthcare providers that have been trained with the continuum of care approach in mind for each country or region. If human and other resources are available to implement the continuum of care as recommended, it is possible to address the issues of the mother and the child at different stages, making it possible to provide health and nutrition practice messages personalised and tailored at different stages to prevent maternal and child mortality⁽¹⁶⁾.

An estimated 700 million women, alive today, were married before their eighteenth birthday⁽²⁸⁾. Preconception care would be a great entry point to discuss the adolescent's nutritional needs and how that affects their pregnancy outcome. Major micronutrients to be assessed and discussed would include iron status and folic acid assessment for the prevention of iron deficiency anaemia and neural tube defects, respectively. A randomised control trial conducted in pre-pregnant women in Tanzanian adolescents aged 15–29 years old found that supplementation of folic acid and iron significantly reduced the risk of hypochromic microcytic anaemia by 30%⁽²⁹⁾. A meta-analysis conducted on micronutrient

supplementation of pregnant women found that folic acid supplementation improved mean birth weight, and significantly reduced the incidence of megaloblastic anaemia by 79%⁽³⁰⁾. Other counselling that would be helpful at this level is delaying childbirth till adult onset for the adolescent⁽³¹⁾.

Maternal care unlevelled playfields

The maternal mortality ratio decreased by 45% between 1990 and 2015 globally⁽¹⁴⁾. In 2009 approximately 1500 women died from preventable causes related to pregnancy and childbirth every day⁽¹⁸⁾, while over the past decade the number has decreased to 800 women. Furthermore, 80% of maternal deaths could have been avoided by access to essential maternity and basic health services⁽³²⁾. Unfortunately, the improvement is not proportional across the globe as the poor countries are still losing a large number of mothers in the process of reproduction⁽¹⁴⁾. These maternal deaths reflect inequalities in access to health services, which highlights the gap between rich and poor⁽²⁾. For example, skilled care during childbirth is only available to 60% of women, and even fewer (less than 40%) receive a postnatal visit according to a review conducted by the International Federation of Red Cross and Red Crescent Societies⁽⁵⁾. As a result of the MDG 5 recommendations, levels of ANC have increased in many parts of the world, but only 46% of women in low-income countries benefit from skilled care during childbirth, leaving millions of births without assistance by a midwife, a doctor or a trained nurse⁽³²⁾. The continuum of care recommends that the mothers receive prenatal micronutrients such as folic acid and calcium in addition to adequate protein and energy, as these are specifically related to the growth of the fetus and the health of the mother, during pregnancy⁽³³⁾. Also, this would be an opportune time to discuss the effect of alcohol, tobacco, pica and other drugs related to the health of the mother and the baby^(34,35). The use of alcohol, tobacco and other drug substances can result a significant number of antenatal complications, neonatal and long-term negative effects in child health. In addition, women that abuse these substances are also less likely to seek prenatal care, higher risk of infections such as HIV, hepatitis or other sexual transmitted infections⁽³⁴⁾. A meta-analysis carried out by Miao, Young and Golden indicated that the consumption of non-food items, such as earth, raw starch and ice generally referred to as pica, was significantly associated with the presence of anaemia, lower Hb and haematocrit concentrations and lower zinc concentrations in plasma⁽³⁵⁾. Understanding that maternal undernutrition is a risk factor for fetal growth, assessment of food insecurity as an underlying cause of nutrient deficiency is critical in achieving the sustainable development goals targeting MCH⁽⁶⁾.

Child services care

A child born in a least developed country is fourteen times more likely to die within first 28 d of life as compared with an industrialised country⁽¹⁸⁾. According to

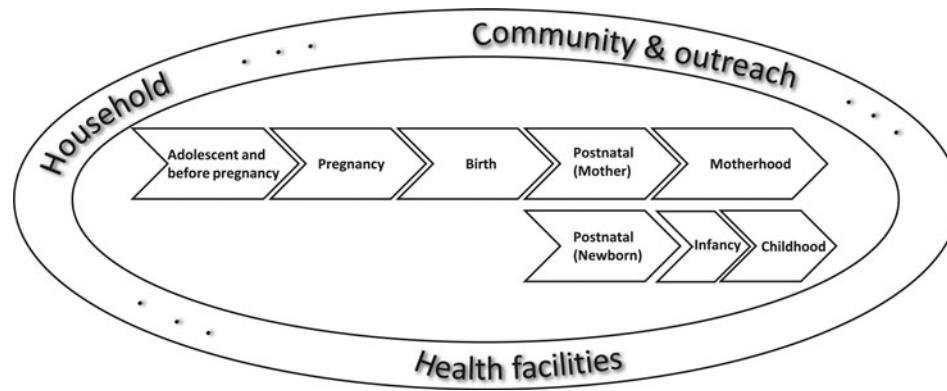


Fig. 1. Continuum of care⁽¹⁶⁾.

the UNICEF predictions, 69 million children under age 5 will die between 2016 and 2030⁽³⁶⁾. In low income countries, the majority of vulnerable mothers are still birthing their children at home unattended or attended by traditional birth attendants. Also, the practice or early clamping of the umbilical cord after birth is the norm. Thus encouraging and teaching the benefits of delayed cord clamping to increase the Hb levels of the newborn is an important first step⁽³⁷⁾. As important as vitamin K supplementation is in preventing Vitamin K deficiency bleeding, to date we do not have a mechanism of providing vitamin K to babies born at home⁽³⁷⁾.

Although there is enough evidence to show that exclusive breastfeeding is associated with infant survival, evidence that exclusive breastfeeding among low-income mothers supports normal growth is unconvincing⁽³⁸⁾. This is shown by the many children that are exclusively breastfed and are stunted as early as age 6 months^(39,40). A study by Brown *et al.* questions the adequacy of milk production on cases where the mother is food insecure or undernourished herself⁽⁴¹⁾. This author recommends promotion and provision of an adequate diverse diet for the mother during the first 6 months of exclusive breastfeeding⁽⁴¹⁾.

The WHO recommends the introduction of safe and nutritious foods in addition to breastfeeding at about age 6 months⁽⁴²⁾. It is, however, important that we understand that for food insecure or low-income households, recommendations alone are not sufficient⁽⁴³⁾. For example, food contamination is a threat to the health and growth of the infant with the introduction of solid foods, underscoring the importance of educating mothers on the principles of food safety⁽⁴⁴⁾. In addition to the provision of food, it is critical to prevent childhood diseases by providing immunisations in a timely manner⁽⁴⁵⁾.

Conceptual healthcare

According to the 2015 Maternal, Newborn and Child Survival report, a total of twenty-five countries achieved their MDG 4 target by reducing childhood mortality by at least 4.4%, while only six countries achieved the MDG 5 target by reducing maternal mortality by at least 5.5%⁽⁴⁶⁾. The purpose of this section is to identify

the factors that contributed to the attainment of the MDG 4 and MDG 5 by at least 5.0 and 5.5% respectively, and determine the level of the intervention, based on the conceptual framework for maternal and neonatal mortality and morbidity established by UNICEF (Table 1)⁽¹⁸⁾.

The Maternal, Newborn and Child Health conceptual framework illustrates the different levels of morbidity and mortality causes starting with basic causes, followed by the underlying causes and direct causes (Fig. 2). The basic causes address societal level interventions such as politics, economics, equality and their influence on overall health and access to resources. The underlying causes, for most part a product of the basic causes, reflect causes at the community and household levels. Unaddressed underlying causes lead to the direct causes assessed at the individual level (Fig. 2)⁽¹⁸⁾.

Factors that contributed to the achievement of Millennium Development Goals 4 and 5

The Countdown to 2015 Maternal, Newborn and Child Survival Report stated the countries that succeeded in both the reduction of child and maternal mortality as Cambodia, Nepal and Rwanda⁽⁴⁶⁾. These three countries targeted all three levels of intervention starting with the basic causes, underlying causes and direct causes of maternal and child mortality. For example, Cambodia targeted the coverage of reproductive and maternal health services and elimination of poverty through a range of for-poor health financing and supply-side policies⁽⁴⁷⁾. Nepal, on the other hand, focused on extending the access and availability of primary care by increasing the human resources for health (nurses, doctors and midwives), training programmes for the health professionals in maternal care, and offering free child birth and travel costs to women. Nepal also improved their community interventions by engaging non-health professionals in providing safe MCH education in men and women^(48,49). Rwanda prioritised reproductive, maternal, newborn and child health throughout its policies and implemented major health sector reforms. For example, they improved the health system through the coordination of different governmental institutions, increased the national expenditures in health, and improved the health workforce and infrastructure. Also, they involved the community by implementing

Table 1. Achievement of Millennium Development Goals (MDG) 4 and 5 on selected countries by level of intervention.

Country	Under-5 mortality Average annual rate of reduction (%) 1990–2015	Maternal mortality Average annual rate of reduction (%) 1990–2013	Level of intervention according to the conceptual framework	Colour and figure code in Fig. 3
Countries with a MDG 4 ≥ 5.0 % and MDG 5 ≥ 5.5 %				
Cambodia	5.6	8.1	Direct, underlying and basic causes	
Nepal	5.5	6.0	Direct, underlying and basic causes	
Rwanda	5.2	6.1*	Direct, underlying and basic causes	
Countries with MDG 4 ≥ 5.0 %				
Bangladesh	5.4	5.0	Direct, underlying and basic causes	
Brazil	5.2	2.4	Direct and underlying causes	
China	6.5	4.7	Direct and underlying causes	
Egypt	5.1	4.1	Direct, underlying and basic causes	
Ethiopia	5.0	5.0	Direct, underlying and basic causes	
Liberia	5.2	2.8	Direct and underlying causes	
Malawi	5.3	3.2	Direct and underlying causes	
Mexico	5.0	2.5	Direct and underlying causes	
Peru	6.2	4.4	Direct, underlying and basic causes	
Countries with MDG 5 ≥ 5.5 %				
Equatorial Guinea	2.8	7.0	Direct, underlying and basic causes	
Eritrea	4.7	6.2	Direct and underlying causes	
Lao PDR	3.6	6.8	Direct, underlying and basic causes	
Sample countries with MDG 4, 5 or both <1.0 %				
Botswana	0.9	3.1	Direct and underlying causes	
Cameroon	1.8	0.9	Direct causes	
Zimbabwe	0.3	0.4†	Direct and underlying causes	

* Significance of colour green is to identify the percentage that is above the stated MDG 4, 5 or both.
 † Significance of colour red is to identify the percentages of the countries that are below the stated MDG 4, 5 or both.

- Interventions at 3 levels and countries that achieved MDG 4 and 5.
- Interventions at 3 levels and countries that achieved MDG 4.
- Interventions at 2 levels (underlying and direct) and countries that achieved MDG 4.
- Interventions at 3 levels and countries that achieved MDG 5.
- Intervention at 2 levels (underlying and direct) and countries that achieved MDG 5.
- Interventions at 2 levels (underlying and direct) and countries that did not achieve MDG 4 and 5.
- Interventions at 1 level (direct) and countries that did not achieve MDG 4 and 5.

different programmes to improve the contraceptive prevalence rates, child immunisation and exclusive breastfeeding. In general, Rwanda prioritised its approaches in the health sector, and other areas such as education, nutrition, water supply and sanitation⁽⁵⁰⁾.

Millennium Developmental Goal 5 achievement. While the 2015 report indicated that no country achieved MDG 5, the preliminary report in 2013 identified countries that achieved MDG 5 (reducing maternal death by 5.5 %) as Equatorial Guinea, Eritrea and Lao



PDR⁽⁴⁶⁾. According to the Countdown to 2015 Maternal, Newborn and Child Survival Report, in 2013, Eritrea, achieved their MDG goal by creating a specific package for maternal and child healthcare and nutrition, which focused on the direct and underlying causes⁽⁴⁶⁾. For example, they improved the knowledge and healthcare skills related to MCH in the population, by giving post abortion care and counselling, advocacy, community mobilisation and capacity building, reorientation of ANC by increasing routine iron, folic acid and vitamin A supplementation, and improving family care practices. These efforts strengthened the health system, improved the attendance at birth and the emergency obstetric care services⁽⁵¹⁾.

Equatorial Guinea, focused on the basic social services such as health, education and protection. Also, the country programmes in coordination with UNICEF and other international agencies worked in the improvement of knowledge in basic care practices starting with the local authorities, community and families⁽⁵²⁾. Lao PDR, focused on decreasing maternal mortality rates by implementing a decree that waived service fees related to childbirth and child health for pregnant women and children under age 5 at all health centres and public hospitals. In addition, to encourage participation at the community level, the operational guidelines included a financial incentive for village health workers who referred pregnant women and children under age 1 year to the health facility⁽⁵³⁾.

Millennium Development Goal 4 Achievement. Bangladesh, Brazil, China, Egypt, Ethiopia, Liberia, Malawi, Mexico and Peru are among the countries that achieved more than 5% reduction in childhood mortality^(54–62). The majority of the countries that achieved MDG 4 focused on the improvement of immunisation coverage and the promotion of exclusive breastfeeding. For example, Mexico focused on the direct and underlying causes by increasing immunisation rates in children, exclusive breastfeeding rates and inclusion of the neonatal screening of metabolic, auditory and retinopathy diseases⁽⁶¹⁾. Other countries focused on all three different levels. For instance, Ethiopia targeted all three levels of intervention in a systematic way. First, they improved the country basic services such as education and healthcare, as well as decentralisation of the policies by including different sectors and institutions for the basic causes of child mortality. Secondly, they improved the coverage of immunisation, the delivery of services to the people in their local communities by training health workers, and the promotion of healthy feeding for the infants and young children. Lastly, they addressed the direct causes by screening children for acute malnutrition, providing therapeutic foods for medically uncomplicated cases, and referring complicated cases to health facilities for admission to inpatient therapeutic feeding services⁽⁵⁸⁾.

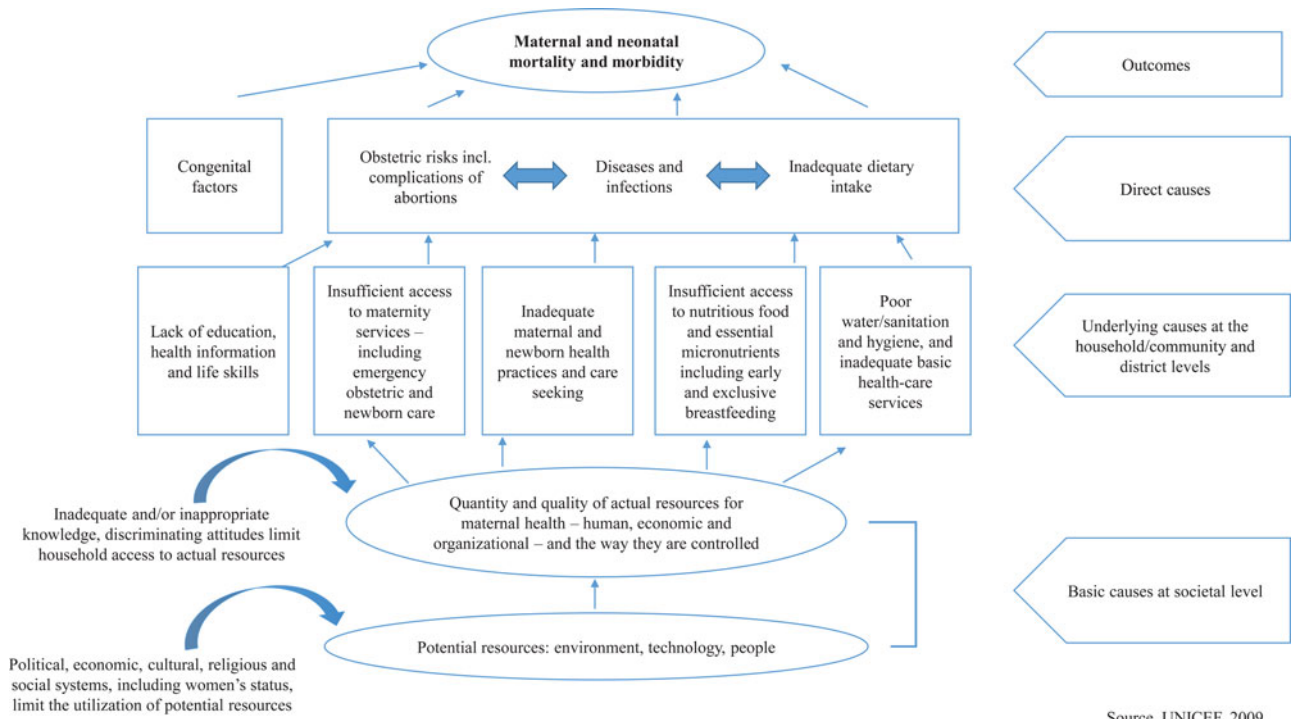
Countries with low rates in the reduction of Millennium Developmental Goals 4 and 5, or both. In an effort to understand factors that hindered the achievement of MDG 4 and 5, three countries that did not reach their target goals were chosen for this review, namely Zimbabwe, Botswana and Cameroon. Zimbabwe only decreased their under-5 and maternal mortality by 0.3 and

0.4%, respectively. Although the country implemented several programmes in MCH at direct and underlying levels, they did not target the basic causes and important barriers at the underlying levels. For example, mothers' religious beliefs hindered accessing healthcare at the health centres and did not include or allow health workers to offer health services at the household level. A country level intervention on the belief system would have encouraged the mothers to seek healthcare and allow healthcare workers to offer help at home. This example underscores the importance of targeting the basic and underlying causes to achieve country wide targets⁽⁶³⁾.

Botswana decreased their child mortality rate by only 0.9 and a 3.1% for MDG 5. The country focused on direct and some indirect interventions, also ignoring the basic causes. At the direct causes level, they improved the immunisation coverage and the management of diseases, while at the underlying level they focused on mobilising healthcare to the communities. However, the implementation of the programmes lacked quantity in health personnel and the inclusion of training for the actual health workers for the improvement of preventive health practices⁽⁶⁴⁾. Cameroon only decreased their maternal mortality by 0.9% from 1990 to 2013 compared with 1.8% for child mortality. Their activities focused on the reduction of the direct causes like emergency obstetric care, but did not target the underlying or basic causes⁽⁶⁵⁾.

In general, the countries that were more likely to achieve MDG 4 and MDG 5 employed tailored interventions targeting affected populations through the direct causes. They also engaged multiple sectors to address the underlying causes by mobilising partners across the society using timely, robust evidence for decision-making and a triple planning approach to consider immediate needs, long-term objectives and adaptation to change. In addition, successful countries established guiding principles that directed progress and aligned stakeholder action⁽⁵⁴⁾. Significant multisector factors for reducing maternal and child mortality included gross domestic product, poverty, skilled birth attendance, doctors per 100 people, immunisations, prenatal care, sanitation, total fertility rate and total years schooling for the females.

As analysed and described earlier, the 2015 MDG report⁽¹⁴⁾ indicated that the regions that succeeded in achieving their MDG goals are the ones that mitigated the problem starting at the basic level, followed by the underlying causes and the direct causes (Fig. 3). Evidences indicate that at least 20% of the burden of disease in children under 5 years old, is related to poor maternal health and nutrition, as well as quality of care at delivery during the newborn period⁽⁶⁾. It is therefore critical that a high proportion of interventions targeting health and survival of under 5 year old children, lay a strong foundation in targeting the pregnant mother and her health and avail skilled services needed during delivery⁽⁶⁶⁾. Evidence further indicates that the nutritional status of a pregnant mother is associated with a healthy birth outcome, underscoring the importance of appropriate interventions for the mother before and during pregnancy⁽⁸⁾. Similarly, it is critical for the mother to be adequately nourished to be able to successfully



Source: UNICEF, 2009

Fig. 2. Conceptual framework for maternal and neonatal mortality and morbidity⁽¹⁸⁾.

breastfeed exclusively for the first 6 months⁽⁶⁷⁾. There is enough evidence that exclusive breastfeeding is associated with the survival of an infant, but based on the number of exclusively breastfed children that are stunted as early as 2 months old, it is critical that the nourishment of the exclusively breastfeeding mother be assured⁽³⁹⁾. It is critical that mothers are provided with nutrition education, appropriate nutritious foods and supplements to complement their diet, especially where food insecurity and poverty are prevalent⁽⁶⁸⁾. This is especially concerning as the 2015 report on the achievements of the MDG indicated that none of the seventy-five countries had been successful in achieving MDG 5 that targeted reducing maternal health by reducing three quarters of the maternal mortality ratio between 1990 and 2015. Conversely, only twenty-five countries met the minimum target for the MDG 4 that states to reduce child mortality by two thirds in the under-five mortality rate, between 1990 and 2015⁽⁶⁹⁾. Lack of adequate services may explain the findings by UNICEF that stated that a child born in a least developed country is fourteen times more likely to die within the first 28 d of life than one born in an industrialised country⁽¹⁸⁾. According to the 2015 MDG report, twenty-five of the seventy-five countries were successful in achieving the MDG 4 targets but none of the countries achieved the MDG 5 targets⁽¹⁴⁾.

Accessing the right care at the right time is crucial

In 2015, an estimated 303 000 women died from pregnancy-related causes⁽⁷⁰⁾, 2.7 million babies died

during the first 28 d of life^(71,72) and 2.6 million babies were stillborn⁽⁷³⁾. Quality healthcare during pregnancy and childbirth could have prevented many of these deaths, yet globally only 64 % of women receive antenatal (prenatal) care four or more times throughout their pregnancy⁽⁷²⁾. ANC is a critical opportunity for health providers to deliver care, support and information to pregnant women^(71,72). This includes promoting a healthy lifestyle, good nutrition, detecting and preventing common childhood diseases, providing family planning counselling and supporting women who may be experiencing intimate partner violence^(71,72).

The WHO new ANC model recommends increasing the number of contacts a pregnant woman has with health providers throughout her pregnancy from four to eight⁽⁷²⁾. Recent evidence indicates that a higher frequency of antenatal contacts by women and adolescent girls to the health providers was associated with a reduced likelihood of stillbirths⁽⁷²⁾. This reduction could be explained by the increased opportunities to detect and manage potential problems⁽⁷²⁾. A minimum of eight contacts for ANC can reduce perinatal deaths by up to eight per 1000 births when compared with a minimum of four visits⁽⁷²⁾. The new model increases maternal and fetal assessments to detect problems, improves communication between health providers and pregnant women, and increases the likelihood of positive pregnancy outcomes. It recommends pregnant women to have their first contact in the first 12 weeks' gestation, with subsequent contacts taking place at 20, 26, 30, 34, 36, 38 and 40 weeks' gestation⁽⁷²⁾. However, for poor resource countries, this level of access and frequency of contact may not materialise

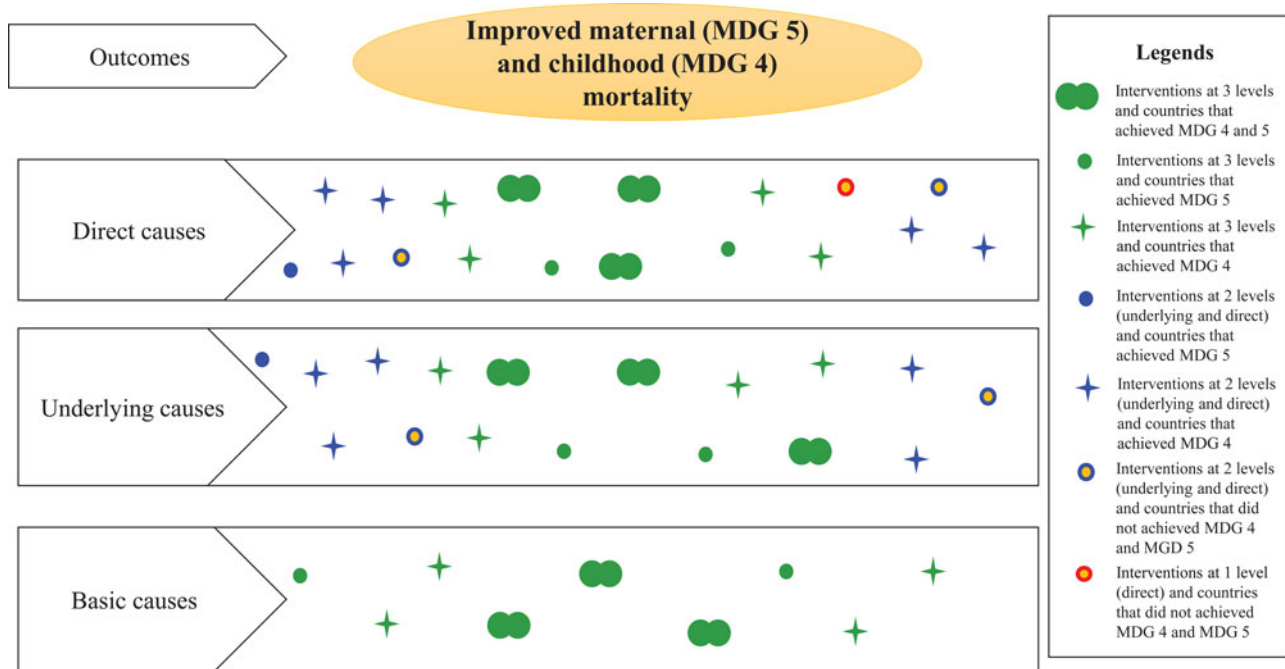


Fig. 3. Level of intervention in selected countries according to the conceptual framework.

unless extensive capacity building is initiated. In addition, the comprehensive nature of integrated healthcare will call for extensive skilled training that might not be possible with the basic training offered to community health workers⁽³⁸⁾. Integrated healthcare requires a broad level of expertise ranging from pre-pregnancy, pregnancy as well as to newborn and infant feeding⁽⁷⁴⁾. We are not convinced that the present community health workers have the required training and competences to offer those service^(1,38,74). The present review recommends simplifying training by forming teams of community health workers to work together with each team member trained in a specific area. For example, community health workers should be trained in groups of three with one specialising in pre-conception and pregnancy, a second specialising in infant feeding from breastfeeding to complementary foods, while yet another health worker, specialising in the healthcare for children 12–59 months and covering immunisation and diseases management⁽¹⁾.

Unfortunately, despite the advances achieved through the MDG in MCH, WHO has projected that if the trends of the past 15 years continue for the next 15 years, by 2030, an estimated 167 million children will still be living in extreme poverty, approximately 3.6 million children under age 5 will die from mostly preventable causes, and approximately 250 000 additional deaths will occur annually from malnutrition, malaria, diarrhoea and heat stress attributable to climate change⁽⁷¹⁾. As a result, during 2014 the UN Open Working Group proposed a set of sustainable development goals with seventeen goals and 169 targets for a 15 year period from 2015 to 2030, which includes thirteen targets related to maternal, newborn and child health⁽⁷⁵⁾.

What is the role of nutrition education in achieving the sustainable development goals?

The purpose of health related interventions is to improve the health of the target population. While major components of improving the health of a population is beyond the control of the target population, for the impact of the interventions to be sustained, behaviour change on part of the target population is imperative⁽⁷⁶⁾. Unfortunately, many MDG, especially MDG 4 and 5, were not designed for the desired behaviour change of the target population. The evaluation and monitoring process emphasised the final outcome measure at the expense of the process and sustainability of the behaviour at the individual, community and country levels. For example, while it is desirable to reduce stunting, it is more important to know that the mothers of the stunted children are highly motivated in care seeking and nutrient-dense complementary food preparation and that they have the ability to purchase and prepare food to maximise nutritional values^(77,78). A study carried out in Nepal found a strong positive relationship between the dietary quality and feeding practices of mothers with the nutritional status of the children. It is critical to not only recommend practices, but teach how to apply the recommendations⁽⁷⁹⁾. In addition, it is critical that the target population have inbuilt triggers for action. For example, a trigger can be hunger symptoms, malnutrition symptoms or timing of messages from the community health workers or peers. The Fogg Behaviour Model asserts that for a behaviour to be sustainably performed, motivation, ability and a trigger are critical factors to be considered for the action of an intervention⁽⁸⁰⁾. All three factors are essential for behaviour sustainability⁽⁸⁰⁾. The

expected health outcome may be a motivating factor for the mother and therefore the benefits of the target behaviour should be well explained in an effort to motivate the mothers⁽⁸¹⁾. To increase motivation, it is critical to make sure that basic needs have been met, and that there are environmental and social support to perform the behaviour⁽⁸²⁾. In addition to motivation, it is critical to assess the ability to perform the desired behaviour and to ensure that the target behaviour is easy to perform. The main purpose of increasing ability is making the behaviour easy to perform⁽⁸³⁾. The third aspect of persuasive behaviour model is setting a trigger. A trigger is a form of a reminder to act, this could be mothers understanding her child's hunger cues, or time to wash hands, or understanding child growth milestones so that she can take the child to the clinic⁽⁸³⁾.

In addition, effective nutrition and health education should identify the behaviour changes that are needed, based on the problem to be solved by the intervention. A proper assessment of the problem will identify the determinants and barriers of the behaviour, and the target population, followed by the intervention plan and related evaluation⁽⁸⁴⁾. In addition, the desired behaviour should be based on evidence and this might be different in different countries⁽⁸⁵⁾.

Conclusions

According to the present review, the 2015 report⁽¹⁴⁾ on the status of the MCH gives us hope in reducing infant and maternal mortality rates and improving the health of the survivors. However, according to WHO projections, unless we change the present trend, by 2030, approximately 3.6 million children under age 5 will die from preventable causes.

An analysis of the interventions that were conducted by selected countries based on their success in achieving their targets for both MDG 4 and 5, indicate that they systematically addressed all three levels of the maternal and child framework starting with the basic or societal causes, underlying causes and finally the direct causes. An important aspect of the interventions conducted by the countries that achieved their goals was capacity building that included increasing healthcare workers and providing them with adequate training.

Conversely, the majority of the countries that did not reach their target did not address concerns at the basic or societal level and most did not include capacity building such as comprehensive training on the protocols for the healthcare workforce, shortage of medical professionals and they included a fee for their basic service. Others designed poor interventions that did not address the causes of the problems such as poor rural transportation, unavailability of drugs and medical supplies and poor quality of water in rural and urban areas.

Going forward to sustainable development goals, it is critical for each country to work on societal level problems, address the cause of the problems by addressing the underlying causes and focus on capacity building. In addition, focusing on behaviour change and

identifying the barriers to change will lead to sustainable changes. As discussed earlier the countries that were more likely to succeed focused on capacity building by training their healthcare and community educators. Nutrition education is a major pillar in maternal and child survival making nutrition education a critical part of any sustainable intervention. The ability to reach the community at all levels with the appropriate intervention a function of funding is imperative. It is therefore critical that the community healthcare professionals understand factors that motivate and limit their target population in the desired behaviour change. In addition, policy makers have an important role in the development and implementation of the programmes in MCH by creating and/or improving the interventions and addressing direct, underlying, and basic causes simultaneously and in collaboration with different institutions and organisations.

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M. M. conceived the idea of the manuscript, conceptualised the direction of the manuscript and revised the first drafts. A. F. M. C. identified the references, drafted the manuscript and designed the figures and table.

References

1. World Bank (2016) *Reproductive, Maternal, Newborn, and Child Health*. Washington, DC. Series: disease control priorities: vol. 2. <http://www.worldbank.org/> (accessed December 2016).
2. Save the Children Federation (2015) *State of World's Mothers: The Urban Disadvantage*. Fairfield: Save the Children Federation, Inc., Bill & Melinda Gates Foundation, and Johnson & Johnson. Available at http://www.savethechildren.org/atf/cf/%7B9def2ebe-10ae-432c-9bd0-df91d2eba74a%7D/SOWM_2015.PDF (accessed December 2016).
3. Abu-Saad K & Fraser D (2010) Maternal nutrition and birth outcomes. *Epidemiol Rev* **32**, 5–25.
4. Lassi ZS, Mansoor T, Salam RA *et al.* (2014) Essential pre-pregnancy and pregnancy interventions for improved maternal, newborn and child health. *Reprod Health* **11**, 1–8.



5. International Federation of Red Cross and Red Crescent Societies (2013) *Maternal, Newborn and Child Health*. Geneva. <http://www.ifrc.org> (accessed December 2016).
6. Black RE, Victora CG, Walker SP *et al.* (2013) Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet* **382**, 427–451.
7. Wu G, Imhoff-Kunsch B & Girard AW (2012) Biological mechanisms for nutritional regulation of maternal health and fetal development. *Paediatr Perinat Epidemiol* **26**, Suppl. 1, 4–26.
8. King JC (2016) A summary of pathways or mechanisms linking preconception maternal nutrition with birth outcomes. *J Nutr* **146**, Suppl., 1437S–1444S.
9. Imdad A & Bhutta ZA (2012) Effects of calcium supplementation during pregnancy on maternal, fetal and birth outcomes. *Paediatr Perinat Epidemiol* **26**, Suppl. 1, 138–152.
10. Hofmeyr GJ, Lawrie TA, Atallah AN *et al.* (2010) Calcium supplementation during pregnancy for preventing hypertensive disorders and related problems. *Cochrane Library* CD001059.pub3.
11. Christian P, Katz J, Wu L *et al.* (2008) Risk factors for pregnancy-related mortality: a prospective study in rural Nepal. *Pub Health* **122**, 161–172.
12. Merchant KM, Villar J & Kestler E (2001) Maternal height and newborn size relative to risk of intrapartum caesarean delivery and perinatal distress. *BJOG* **108**, 689–696.
13. Kozuki N, Katz J, Lee AC *et al.* (2015) Short maternal stature increases risk of small-for-gestational-age and pre-term births in low-and middle-income countries: individual participant data meta-analysis and population attributable fraction. *J Nutr* **145**, 2542–2550.
14. UN (2015) *The Millennium Development Goals Report 2015*. [http://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG%202015%20rev%20\(July%201\).pdf](http://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG%202015%20rev%20(July%201).pdf).
15. UNICEF (2015) *Levels and Trends in Child Mortality Report 2015*. http://www.who.int/maternal_child_adolescent/documents/levels_trends_child_mortality_2015/en/ (accessed December 2016).
16. Kerber KJ, de Graft-Johnson JE, Bhutta ZA *et al.* (2007) Continuum of care for maternal, newborn, and child health: from slogan to service delivery. *Lancet* **370**, 1358–1369.
17. Black RE, Allen LH, Bhutta ZA *et al.* (2008) Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet* **371**, 243–260.
18. UNICEF (2009) *The State of The World's Children 2009: Maternal and Newborn Health*. <https://www.unicef.org/sowc09/docs/SOWC09-FullReport-EN.pdf>.
19. UNICEF (2013) *The State of the World's Children: Children with Disabilities*. https://www.unicef.org/sowc2013/files/SWCR2013_ENG_Lo_res_24_Apr_2013.pdf.
20. International Vaccine Center (IVAC), Johns Hopkins Bloomberg School of Public Health (2015). *Pneumonia and Diarrhea Progress Report 2015: Sustainable Progress in the Post-2015 Era*. <http://www.jhsph.edu/research/centers-and-institutes/ivac/resources/IVAC-2015-Pneumonia-Diarrhea-Progress-Report.pdf>.
21. Stoltenberg J (2007) *Speech by Prime Minister of Norway at the World Health Assembly*. Geneva, Switzerland: WHO, May 2007. <http://www.norwayemb.org.in/News+and+Events/speech+at+geneva.htm> (accessed December 2016).
22. Lawn JE, Tinker A, Munjanja SP *et al.* (2006) Where is maternal and child health now? *Lancet* **368**, 1474–1477.
23. Gill K, Pande R & Malhotra A (2007) Women deliver for development. *Lancet* **370**, 1347–1357.
24. Tinker A, ten Hoop-Bender P, Azfar S *et al.* (2005) A continuum of care to save newborn lives. *Lancet* **365**, 822–825.
25. Tran NT, Portela A, de Bernis L *et al.* (2014) Developing capacities of community health workers in sexual and reproductive, maternal, newborn, child, and adolescent health: a mapping and review of training resources. *PLoS ONE* **9**, e94948.
26. Cancedda C, Farmer PE, Kerry V *et al.* (2015) Maximizing the impact of training initiatives for health professionals in low-income countries: frameworks, challenges, and best practices. *PLoS Med* **12**, available at <https://doi.org/10.1371/journal.pmed.1001840>.
27. Jongh T, Gurol-Urganci I, Allen E *et al.* (2016) Barriers and enablers to integrating maternal and child health services to antenatal care in low and middle income countries. *BJOG* **123**, 549–557.
28. UNICEF (2014) *Ending Child Marriage: Progress and Prospects*. New York: UNICEF. https://www.unicef.org/media/files/Child_Marriage_Report_7_17_LR.pdf.
29. Gunaratna NS, Masanja H, Mrema S *et al.* (2015) Multivitamin and iron supplementation to prevent periconceptional anemia in rural Tanzanian women: a randomized, controlled trial. *PLoS ONE* **10**, available at <https://doi.org/10.1371/journal.pone.0121552>.
30. Haider BA & Bhutta ZA (2012) Multiple-micronutrient supplementation for women during pregnancy. *Cochrane Library* CD004905.
31. Jaffee S, Caspi A, Moffitt TE *et al.* (2001) Why are children born to teen mothers at risk for adverse outcomes in young adulthood? Results from a 20-year longitudinal study. *Dev Psychopathol* **13**, 377–397.
32. WHO (2014) Maternal mortality fact sheet. http://apps.who.int/iris/bitstream/10665/112318/1/WHO_RHR_14.06_eng.pdf?ua=1 (accessed December 2016).
33. Lassi ZS, Dean SV, Mallick D *et al.* (2014) Preconception care: delivery strategies and packages for care. *Reprod Health* **11**, Suppl., 1–17.
34. Wong S, Ordean A, Kahan M *et al.* (2011) Substance use in pregnancy. *J Obstet Gynaecol Can* **33**, 367–384.
35. Miao D, Young SL & Golden CD (2015) A meta-analysis of pica and micronutrient status. *Am J Hum Biol* **27**, 84–93.
36. UN Interagency Group for Child Mortality Estimation (2015). *Levels and Trends in Child Mortality Report 2015: Estimates Developed by the UN INTERAGENCY Group for Child Mortality Estimation, United Nations Children's Fund*. New York. http://www.unicef.org/publications/files/Child_Mortality_Report_2015_Web_9_Sept_15.pdf.
37. Rabe H, Diaz-Rossello JL, Duley L *et al.* (2012) Effect of timing of umbilical cord clamping and other strategies to influence placental transfusion at preterm birth on maternal and infant outcomes. *Cochrane Library*.
38. Bhutta ZA, Des JK, Rizvi A *et al.* (2013) Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost? *Lancet* **382**, 452–477.
39. Patwari AK, Kumar S & Beard J (2015) Undernutrition among infants less than 6 months of age: an underestimated public health problem in India. *Matern Child Nutr* **11**, 119–126.
40. Young M & Martorell R (2013) The public health challenge of early growth failure in India. *Eur J Clin Nutr* **67**, 496–500.
41. Brown KH, Akhtar NA, Robertson AD *et al.* (1986) Lactational capacity of marginally nourished mothers: relationships between maternal nutritional status and quantity and proximate composition of milk. *Pediatrics* **78**, 909–919.
42. WHO (2002) *Report of Informal Meeting to Review and Develop Indicators for Complementary Feeding*.



- Washington, DC. http://www.who.int/nutrition/publications/report_of_informal_meeting_for_cf.pdf
43. Lassi ZS, Das JK, Zahid G *et al.* (2013) Impact of education and provision of complementary feeding on growth and morbidity in children less than 2 years of age in developing countries: a systematic review. *BMC Pub Health* **13**, Suppl. 3, 1–13.
 44. Motarjemi Y, Käferstein F, Moy G *et al.* (1993) Contaminated weaning food: a major risk factor for diarrhoea and associated malnutrition. *Bull World Health Org* **71**, 79.
 45. Guerra FA (2007) Delays in immunization have potentially serious health consequences. *Paediatr Drugs* **9**, 143–148.
 46. UNICEF & WHO (2015) *A Decade of Tracking Progress for Maternal, Newborn and Child Survival: the 2015 Report*. http://www.countdown2015mnch.org/documents/2015Report/Countdown_to_2015-A_Decade_of_Tracking_Progress_for_Maternal_Newborn_and_Child_Survival-The_2015Report-Conference_Draft.pdf.
 47. Dingle A, Powell-Jackson T & Goodman C (2013) A decade of improvements in equity of access to reproductive and maternal health services in Cambodia, 2000–2010. *Int J Equity Health* **12**, 51.
 48. Malla D, Giri K, Karki C *et al.* (2011) Achieving millennium development goals 4 and 5 in Nepal. *BJOG* **118**, Suppl. 2, 60–68.
 49. Government of Nepal, National Planning Commission and United Nations (2013) *Nepal Millennium Development Goals: Progress Report 2013*. http://www.np.undp.org/content/dam/nepal/docs/reports/millennium%20development%20goals/UNDP_NP_MDG_Report_2013.pdf.
 50. Ministry of Health Rwanda, PMNCH, WHO, World Bank, AHPSS and Participants in the Rwanda Multistakeholder Policy Review (2014) Success Factors for Women's and Children's Health: Rwanda. http://www.who.int/pmnch/knowledge/publications/rwanda_country_report.pdf (accessed December 2016).
 51. Ministry of Health Eritrea (2010) Health Sector Strategic Development Plan HSSDP: 2010–2014. http://www.nationalplanningcycles.org/sites/default/files/planning_cycle_repository/eritrea/eritrea_health_strategic_plan.pdf.
 52. UNICEF (2013) Equatorial Guinea Country Programme Document 2013–2017. https://www.unicef.org/about/execboard/files/2012-PL37_Equatorial_Guinea_CPD-final_approved-English.pdf.
 53. Government of the Lao PDR and the United Nations (2013) *The Millennium Development Goals Progress Report for the Lao PDR 2013*. http://www.la.undp.org/content/lao_pdr/en/home/library/mdg/mdgs-progress-report-lao-pdr-2013.html (accessed December 2016).
 54. Kuruvilla S, Schweitzer J, Bishai D *et al.* (2014) Success factors for reducing maternal and child mortality. *Bull World Health Org* **92**, 533–544.
 55. El Arifeen S, Hill K, Ahsan KZ *et al.* (2014) Maternal mortality in Bangladesh: a countdown to 2015 country case study. *Lancet* **384**, 1366–1374.
 56. Cavalcante A, Correia LL, Campos JS *et al.* (2015) Reducing child mortality: the contribution of Ceará state, northeast of Brazil, on achieving the millennium development goal 4 in Brazil. *Matern Child Health J* **19**, 700–706.
 57. Kanyuka M, Ndawala J, Mleme T *et al.* (2016) Malawi and millennium development goal 4: a countdown to 2015 country case study. *Lancet Glob Health*, available at [https://doi.org/10.1016/S2214-109X\(15\)00294-6](https://doi.org/10.1016/S2214-109X(15)00294-6).
 58. Tadesse M, Defar A, Gatachew T *et al.* (2015) Countdown to 2015: Ethiopia's progress towards reduction in under-five mortality: 2014 country case study. <http://researchonline.lshtm.ac.uk/2551490/1/Ethiopia%20Countdown%20Case%20Study%20Final%20Report.pdf>.
 59. Moucheraud C, Owen H, Singh NS *et al.* (2016) Countdown to 2015 country case studies: what have we learned about processes and progress towards MDGs 4 and 5? *BMC Pub Health* **16**, 794.
 60. Huicho L, Segura ER, Huayanay-Espinoza CA *et al.* (2016) Child health and nutrition in Peru within an anti-poverty political agenda: a countdown to 2015 country case study. *Lancet Glob Health*, available at [http://dx.doi.org/10.1016/S2214-109X\(16\)00085-1](http://dx.doi.org/10.1016/S2214-109X(16)00085-1).
 61. Mexico's Secretariat of Governance (2013) Health Sector Program 2013–2018. http://www.dof.gob.mx/nota_detalle.php?codigo=5326219&fecha=12/12/2013 (in Spanish; accessed December 2016).
 62. Ministry of Health and Population, Egypt, Partnership for Maternal, Newborn & Child Health, WHO, World Bank and Alliance for Health Policy and Systems Research (2014) Success factors for women's and children's health: Egypt. http://www.who.int/pmnch/knowledge/publications/egypt_country_report.pdf?ua=1.
 63. National Child Survival Strategy for Zimbabwe 2010–2015 (2010) https://www.unicef.org/zimbabwe/Young_Child_Survival_Doc-Complete.pdf.
 64. Office for Africa (2014) Botswana MDG Goal 4: Reduce Child Mortality. http://www.who.afro.who.int/profiles_information/index.php/Botswana:MDG_Goal_4:_Reduce_child_mortality (accessed December 2016).
 65. Mbiydenyuy NE (2013) Addressing maternal deaths in rural Cameroon. http://primelactationcentercameroon.blogspot.com/2013/01/addressing-maternal-deaths-in-rural_25.html (accessed December 2016).
 66. Ramakrishnan U, Grant F, Goldenberg T *et al.* (2012) Effect of women's nutrition before and during early pregnancy on maternal and infant outcomes: a systematic review. *Paediatr Perinat Epidemiol* **26**, Suppl. 1, 285–301.
 67. Chapman DJ & Nommensen-Rivers L (2012) Impact of maternal nutritional status on human milk quality and infant outcomes: an update on key nutrients. *Adv Nutr: Int Rev J* **3**, 351–352.
 68. Dollahite J, Olson C & Scott-Pierce M (2003) The impact of nutrition education on food insecurity among low-income participants in EFNEP. *Fam Consum Sci Res J* **32**, 127–139.
 69. UN (2015) *Department of Economic and Social Affairs of the United Nations. Department of PUBLIC Information. The Millennium Development Goals Report 2015*. [http://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG%202015%20rev%20\(July%201\).pdf](http://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG%202015%20rev%20(July%201).pdf).
 70. Alkema L, Chou D, Hogan D *et al.* (2016) 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* **387**, 462–474.
 71. UNICEF (2016) The state of the world's children 2016: a fair chance for every child. https://www.unicef.org/publications/files/UNICEF_SOWC_2016.pdf.
 72. WHO (2016) Pregnant women must be able to access the right care at the right time, says WHO. <http://www.who.int/mediacentre/news/releases/2016/antenatal-care-guidelines/en/> (accessed December 2016).
 73. Cousens S, Blencowe H, Stanton C *et al.* (2016) National, regional, and worldwide estimates of stillbirth rates in 2015, with trends from 2000: a systematic analysis. *Lancet Glob Health*. Available at [http://dx.doi.org/10.1016/S2214-109X\(15\)00275-2](http://dx.doi.org/10.1016/S2214-109X(15)00275-2).



74. Bhutta ZA, Lassi ZS, Pariyo G *et al.* (2010) Global experience of community health workers for delivery of health related millennium development goals: a systematic review, country case studies, and recommendations for integration into national health systems. *Global Health Workforce Alliance* **1**, 249–261.
75. UN (2016) *The Sustainable Development Goals Report 2016*. <http://unstats.un.org/sdgs/report/2016/The%20Sustainable%20Development%20Goals%20Report%202016.pdf>.
76. Kumar V, Kumar A, Ghosh AK *et al.* (2015) Enculturating science: community-centric design of behavior change interactions for accelerating health impact. *Semin Perinatol* **39**, 393–415.
77. D'Alimonte M, Deshmukh D, Jayaraman A *et al.* (2016) Using positive deviance to understand the uptake of optimal infant and young child feeding practices by mothers in an urban slum of Mumbai. *Matern Child Health J* **20**, 1133–1142.
78. Lingam R, Gupta P, Zafar S *et al.* (2014) Understanding care and feeding practices: building blocks for a sustainable intervention in India and Pakistan. *Ann N Y Acad Sci* **1308**, 204–217.
79. Locks LM, Pandey PR, Osei AK *et al.* (2015) Using formative research to design a context-specific behaviour change strategy to improve infant and young child feeding practices and nutrition in Nepal. *Matern Child Nutr* **11**, 882–896.
80. Fogg BJ (2009) A behavior model for persuasive design. In *Proceedings of the 4th international Conference on Persuasive Technology*, p. 40. New York: ACM.
81. Davis AM, Wambach KA, Nelson EL *et al.* (2014) Health behavior change in pregnant women: a two-phase study. *Telemed e-Health* **20**, 1165–1169.
82. Jensen ML, Frongillo EA, Leroy JL *et al.* (2016) Participating in a food-assisted maternal and child nutrition and health program in rural Guatemala alters household dietary choices. *J Nutr* **146**, 1593–1600.
83. Newson RS, Lion R, Crawford RJ *et al.* (2013) Behaviour change for better health: nutrition, hygiene and sustainability. *BMC Public Health* **13**, 1.
84. Ritchie LMP, Khan S, Moore JE *et al.* (2016) Low-and middle-income countries face many common barriers to implementation of maternal health evidence products. *J Clin Epidemiol* **76**, 229–237.
85. Vélez LF, Sanitato M, Barry D *et al.* (2014) The role of health systems and policy in producing behavior and social change to enhance child survival and development in low-and middle-income countries: an examination of the evidence. *J Health Commun* **19**, Suppl. 1, 89–121.