

Maternal mortality in developing countries: challenges in scaling-up priority interventions

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Although maternal mortality is a significant global health issue, achievements in mortality decline to date have been inadequate. A review of the interventions targeted at maternal mortality reduction demonstrates that most developing countries face tremendous challenges in the implementation of these interventions, including the availability of unreliable data and the shortage in human and financial resources, as well as limited political commitment. Examples from developing countries, such as Sri Lanka, Malaysia and Honduras, demonstrate that maternal mortality will decline when appropriate strategies are in place. Such achievable strategies need to include redoubled commitments on the part of local, national and global political bodies, concrete investments in high-yield and cost-effective interventions and the delegation of some clinical tasks from higher-level healthcare providers to mid- or lower-level healthcare providers, as well as improved health-management information systems.

In recent years, increasing attention has been paid to maternal mortality trends in developing countries, especially in the context of the United Nations Millennium Declaration. The fifth Millennium Development Goal (MDG) initially articulated one target: “to reduce maternal mortality ratio (MMR) by three quarters by 2015” [201]. More recently, a second target – to achieve universal reproductive health – was added to the fifth MDG. Despite the fact that 189 countries have signed the Millennium Declaration, a United Nations progress report from 2008 stated that “Maternal mortality [has] remained unacceptably high across much of the developing world, constituting the area of least progress among all MDGs” [201]. Moreover, with a few notable exceptions, little progress has been reported in the global decline of maternal mortality over the past decade [1].

This article reviews approaches to the reduction of maternal mortality in developing countries and describes the challenges in the implementation of the current priority interventions. By highlighting examples of developing countries that have successfully lowered the MMR, we propose potentially achievable strategies that could mitigate some of the obstacles that countries face in MMR reduction.

Materials & methods

A review of the available literature was carried out using MEDLINE, PubMed, Web of Science, JStor and Google Scholar. In addition, articles

from the WHO, the World Bank, UNICEF and the United Nations Population Fund (UNFPA), as well as other relevant articles and websites, were read thoroughly on the topics of safe motherhood interventions and the challenges faced in implementing them. Maternal mortality levels, trends and cause distribution used in this paper represent the most current available published data. These estimates come from the WHO or published data commissioned by the Maternal Mortality Working Group [1,2]. The group was established in 2006 to improve maternal mortality estimation methods, generate new estimates for 2005 and to assess trends since 1990.

Priority interventions were identified and assessed for their potential impact on maternal mortality based on the WHO Mother Baby Package (APPENDIX A), the Cochrane Library and the WHO Reproductive Health Library. Maternal health interventions targeting the most frequent direct or indirect causes of maternal death were prioritized. Innovative interventions and technologies that have not been implemented on a large-scale but for which evidence suggests potential for a large-scale impact were also included.

Levels, trends & causes of maternal mortality

Maternal death is defined by “the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the

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duration or site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental causes” [3]. Every year, upwards of 500,000 women die of maternal causes worldwide. In 2005, the global estimate for MMR was 402 maternal deaths per 100,000 live-births, with 99% of the burden borne by developing nations (FIGURE 1) [1].

Sub-Saharan Africa accounts for 50% of all maternal deaths globally [1]. Of those, 70–80% are due to direct obstetric causes (i.e., complications of pregnancy, labor, delivery or the postpartum period) [4]. FIGURE 1 demonstrates the global distribution of the causes of maternal death. Indirect causes of maternal death account for women who die from any other disease during the maternal period (pregnancy and up to 42 days postpartum or postabortion). Indirect causes represent a varying spectrum of the burden of maternal deaths, from an average of approximately 4% in Latin America up to 13% in Asia and 17% in Africa [4]. Overall disparities in maternal mortality between developed and developing countries are vast and unjustified, clearly illustrating the gap in access to quality healthcare services. In an analysis of 34 worldwide databases by Khan *et al.*, the ranges found in the proportion of deaths attributable to a specific maternal cause across the region are good evidence of widespread social inequality; for example, taking the primary cause of global maternal deaths – postpartum hemorrhage (PPH) – Khan *et al.* found that, in Africa alone, the percentage contribution of PPH to total maternal deaths varied between 13.3 and 43.6% [4].

Even within individual low-resource countries, inequities in the risk of maternal death are prevalent [5]. The result is not just reflected by the approximately 500,000 maternal deaths each year; it also leaves 10–20 million women affected by various degrees of illness related to pregnancy and childbirth [6].

Historical perspective

In the mid- to late-19th century, the first phase of maternal mortality decline was observed in northwestern Europe (Sweden, Norway, Denmark and the Netherlands) and several decades later in Britain and the USA [7]. Based on data from Sweden from between 1870 and 1900, the first phase of this reduction is attributed to the effectiveness of skilled attendance at childbirth. A second phase of maternal mortality decline was seen between the 1930s and the 1960s, and was a result of many advances in

medicine, including cesarean section, penicillin, blood transfusion, institutional delivery and antenatal care [8]. Maternal mortality decline in the USA and the Netherlands observed in the 1990s was also attributed to changes in population age-structure and parity [9,10].

Priority interventions to reduce maternal mortality

The following interventions, described in the order of their probable occurrence, are known for their potential to reduce maternal morbidity and mortality. The majority of the interventions are directed at treating the five primary obstetric causes of maternal death: hemorrhage, hypertensive disorders of pregnancy, puerperal sepsis, unsafe abortion and prolonged/obstructed labor.

Family planning

Effective family planning programs address the largely unmet need for contraception (BOX 1) by providing information, counseling and a range of temporary and permanent contraceptive methods (APPENDIX B1) [11,12]. Family planning reduces maternal mortality by enabling women to prevent conception, which in turn eliminates the risk of unwanted pregnancy and mortality related to pregnancy or childbirth [13].

Prevention of sexually transmitted infections & HIV infection

Effective prevention of sexually transmitted infections (STIs)/HIV has the potential to avert future maternal morbidity and mortality and mother-to-child transmission of STIs/HIV [14]. Strategies include interventions to increase knowledge and reduce risk-taking behavior, voluntary (or routine) HIV counseling and testing, antiretroviral treatment (including prevention of mother-to-child transmission) and referrals to sexual/reproductive health services, such as STI treatment and family planning [202].

Comprehensive abortion care

Comprehensive abortion care is an umbrella term for the safe termination of a pregnancy and postabortion care (PAC), which includes postabortion contraceptive services. Safe termination of a pregnancy can be carried out using surgical methods, such as vacuum aspiration, or by using medication (e.g., misoprostol and mifepristone, or misoprostol alone) [15,16]. Comprehensive abortion care averts the possibility of injury or death owing to unsafe abortion, as well as eliminating the chance that a woman will die from any other direct causes related to

pregnancy [17]. In places where safe abortion is easily available, abortion-related mortality tends to be low [18]. However, even in countries with highly restrictive abortion laws, good quality PAC can make a significant difference in reducing mortality resulting from unsafe abortion [19]. A critical but often overlooked component of PAC is postabortion contraceptive services [20]. Offering women the option of immediate provision of a contraceptive method reduces the risk for repeated abortions and subsequent unwanted pregnancies [20,21]

Antenatal care

Antenatal care (APPENDIX B2) detects and manages conditions during pregnancy that have the potential to lead to adverse maternal outcomes [22,23]. In order to prevent maternal death, detection of hypertension, proteinuria, STIs/HIV, anemia and fetal malpresentation are particularly important, as is educating women and their families to recognize and respond to danger signs during pregnancy [22,24].

Emergency & comprehensive emergency obstetric care

To avoid the direct causes of maternal mortality, the WHO recommends that for every 500,000 people, there should be at least four facilities with basic emergency obstetric care (EmOC) and one facility with comprehensive EmOC. Basic EmOC consists of interventions that do not include surgery, such as antibiotics, oxytocics, anticonvulsants, manual removal of placenta, assisted vaginal delivery and the removal of retained products. Comprehensive EmOC includes all basic EmOC interventions as well as the ability to perform cesarean sections and blood transfusion [25]. More specific details of the available priority interventions by direct cause of maternal death are described in the following sections.

Management of antepartum hemorrhage

Incidence of antepartum hemorrhage is estimated at 3.5% of all pregnancies [26]. In cases of antepartum hemorrhage, close monitoring of

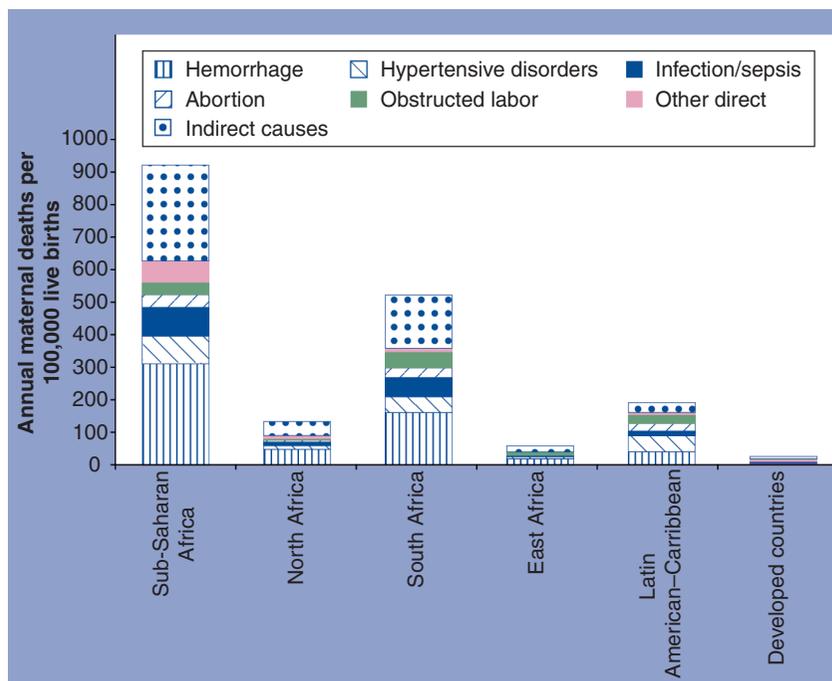


Figure 1. Maternal mortality estimates by cause and world region. Adapted from [1,2].

the amount of bleeding is necessary, but unnecessary vaginal examinations are to be avoided in order to prevent the risk of infection. To prevent shock, administration of iv. fluids and blood transfusion may be necessary, and delivery must be expedited [27]. The type of delivery (e.g., induced vaginal or cesarean) depends upon the severity of bleeding, as well as whether the fetus is alive (APPENDIX B3).

Management of puerperal sepsis

Aseptic techniques are essential in preventing puerperal sepsis. All delivery spaces must be clean, birthing attendants must have clean hands and instruments used during delivery and to cut the umbilical cord must be sterile. If a fever is present (oral temperature: 38.5°C/101.3°F) or if the membranes have been ruptured for more than 12 h, infection is likely to occur. Treatment includes antibiotics, iv. fluids and blood transfusion if needed. In some instances, surgical procedures are necessary to manage thrombophlebitis (blood clots in veins that can cause pain and

Box 1. The unmet need for family planning.

The unmet need for family planning measures the proportion of women who wish to delay or end childbearing but who are not using any method of contraception [17]. In sub-Saharan Africa, levels of unmet need are the highest; nearly a quarter of married or cohabitating women in sub-Saharan Africa (range: 13–38%) and 9% of sexually active, unmarried women (range: 0.3–18%) are not using contraception but report that they currently wish to delay or avoid future pregnancies [12].

inflammation) or drain pelvic abscesses (localized pus in lower abdominal or pelvic regions) (APPENDIX B4) [27].

Management of eclampsia

If a woman presents with proteinuria and convulsions, eclampsia should be suspected and supportive air management may be necessary. Healthcare providers can use antihypertensives to control increases in blood pressure and magnesium sulphate is the treatment of choice to control convulsions [27]. In eclamptic patients, urinary output and changes in blood pressure must be monitored in order to measure the severity of the hypertensive disorder [28]. Patellar reflexes and respiration rates should be observed in order to prevent magnesium toxicity during the administration of magnesium sulphate [26,29,30]. Most importantly, labor must be induced to deliver the fetus immediately [27]. Although there is evidence that antihypertensives reduce severe hypertension during pregnancy by as much as 50%, there is no evidence to suggest that they prevent pre-eclampsia. However, oral labetalol has been used in the treatment and management of hypertension in pre-eclamptic women, although further research is needed to warrant recommending its use in the management of eclampsia (APPENDIX B5.1) [31,32]. A recent review states that large randomized controlled trials are urgently needed in order to determine the use and potential of antihypertensives during pregnancy (APPENDIX B5) [33].

Management of obstructed/prolonged labor

Healthcare providers use a partograph (for monitoring fetal presentation, head engagement and fetal heart sounds; see APPENDIX B6.1) in order to help to determine whether a woman is presenting with obstructed or prolonged labor. If the membranes have not ruptured in cases of obstructed or prolonged labor, artificial rupture may be required. However, artificial rupture of membranes is questionable if the mother is HIV-positive, since it may increase the risk of infection to the fetus. Vacuum extraction of the fetus, labor induction (using oxytocin or misoprostol) or cesarean section may be necessary when vaginal delivery is not possible in order to quickly deliver the fetus before fetal demise. During obstructed labor, cesarean section is recommended. Symphysiotomy, the surgical division of the cartilage of the symphysis pubis to widen the pelvis for delivery, may also be performed (APPENDIX B6) [27].

Management of postpartum hemorrhage

For PPH prevention, active management of the third stage of labor (AMTSL) is recommended [34,35]. AMTSL involves the administration of intramuscular oxytocin, controlled cord traction and uterine massage after delivery of the placenta [35]. In the absence of AMTSL, the WHO “strongly” recommends using misoprostol for PPH prevention [36]. Although a “weaker” recommendation, the WHO also advises the use of external compression of the abdominal aorta, or a uterine balloon tamponade, when appropriate care is not available [36,37]. When hemorrhage is established, further uterotonics (i.e., oxytocin or misoprostol) are required for the treatment of PPH. Depending on the severity, iv. fluids and blood transfusion may also be necessary [27]. Surgical procedures may also be considered if all other interventions have failed (APPENDIX B7) [27,38,39].

Postpartum care

Postpartum care is an umbrella term for a number of interventions, including: early detection and management of obstetric complications immediately after delivery; education and provision of contraception for birth-spacing or limiting; counseling and support for breastfeeding; voluntary counseling and testing for HIV; advice and recommendation regarding postnatal nutrition; information regarding self-care/hygiene (including warning signs of infection); tetanus toxoid immunizations; and social and psychological support [40].

Challenges in implementation

Fierce debate over the effectiveness and prioritization of interventions has crippled global progress in the reduction of maternal mortality [13]. From the 1960s to the 1980s, safe motherhood strategies focused on antenatal care (risk scoring and management) and training traditional birth attendants (TBAs) in clean delivery and timely referral [41]. As the field developed and knowledge of the causal pathways that lead to maternal mortality improved, many scholars began to question the wisdom of investing in these two areas [30,42]. It became clear that many detectable symptoms that are observable during pregnancy had poor predictive power for maternal mortality [43,44]. Furthermore, the evidence that TBA training had had a significant impact on maternal mortality was inconclusive at best [28,45,46].

Both the antenatal care strategy and the TBA-training strategy relied on the referral of higher-risk women, with the assumption that these

women would receive appropriate interventions as needed. In reality, numerous practical barriers hindered referral, especially for impoverished women living in remote rural areas [47–49]. Thus, by the late 1990s, the pendulum had swung towards an intrapartum care strategy that prioritized training skilled birth attendants (SBAs) and improving access to EmOC facilities [5,13].

Challenges to the intrapartum care model

The development of the intrapartum care model was based on overwhelming evidence that maternal mortality is lower among women who deliver with skilled birth assistance (compared with lay attendants) and among women who deliver in a health facility (compared with home deliveries) [203]. Developing countries that invested in both strategies have been able to achieve significant reductions in maternal mortality [50]. However, country-specific factors, such as insufficient political commitment, low numbers of skilled healthcare providers and the inability to retain SBAs in priority areas can severely impede the progress of an intrapartum care strategy [51,52]. At present, as the safe motherhood community watches progress towards the fifth MDG stagnate, many researchers have voiced concern regarding the feasibility of this strategy in achieving universal coverage. In the past 5 years, a growing number of maternal and child-health experts have argued that community-based interventions and improved access to essential drugs are a necessary supplement to current efforts in regions still plagued by high maternal mortality [53–58].

Debate over task-shifting

A parallel debate within the safe motherhood community is the appropriate scope of practice for mid-level and lower-level healthcare providers [59]. A growing body of evidence indicates that mid-level healthcare providers can safely and effectively perform medical tasks that have traditionally been performed by physicians [60,61]. Well-trained community-based healthcare providers are also beginning to assume responsibility for tasks that were previously conducted by mid-level healthcare providers [20]. However, demedicalization and decentralization of health services remains controversial, with representatives from the medical establishment, policy circles and government ministries hesitant to implement sweeping changes. Concerns have been voiced regarding the quality of care, the logistics of supervision and the transfer of control away from the medical establishment [62–65].

Lack of skilled healthcare providers

Low access to skilled healthcare providers is one of the major challenges facing developing countries. The fifth MDG called for improved access to skilled attendance at birth, but the number of nursing and midwifery staff in Africa is only 11 per 10,000 population, compared with 79 per 10,000 in Europe. The WHO estimates that countries with fewer than 23 skilled healthcare providers (i.e., physicians, nurses and midwives) per 10,000 population will not be able to bring essential interventions for the MDGs up to a nationwide scale [66,67]. Even if sufficient investments in training new healthcare providers are made, poorer countries are challenged by the difficulty of retaining nurses and midwives in areas of high need [68].

Missed opportunities in training

A logical first-step in tackling training needs in developing countries is to address the omission of essential knowledge and skill training from the curricula of medical and nursing schools. Medical and nursing students are highly influenced by the subjects and methods they are taught. Many clinicians in developing countries have insufficient opportunities to update their knowledge and skills through continuing education, which has adverse implications for patients [69]. In-service training opportunities in developing countries are frequently designed for physicians, which excludes interested mid-level healthcare providers who have appropriate levels of clinical competence [59,70]. These missed opportunities create health-system inefficiencies and result in limited access to skilled healthcare [51].

The persistent challenge of high fertility

In many fora addressing the problem of maternal mortality, demographic considerations are overlooked, even though high fertility is closely tied to maternal mortality. In countries where total fertility rates (TFRs) are high, women face increased risks in pregnancy and childbirth, owing to short birth intervals and births occurring too early or late in the reproductive lifespan. Sub-Saharan Africa has an average TFR of 5.4, with 13 countries in the region exceeding 6.0 [71]. This is a major concern for the most vulnerable women because poverty, low educational attainment and poor access to healthcare increases the risks of reproductive morbidities and maternal mortality resulting from frequent pregnancies, abortion or childbirth [24,72,203]. Even as birth rates decline, the

effect of population momentum means there will be larger numbers of women entering reproductive age than have existed in the past. With more women needing maternal healthcare services, safe motherhood programs will have to stretch meager resources even more thinly. Thus, the number of SBAs and EmOC facilities that are required today will be grossly inadequate in 5 years' time. Rapid improvements in family planning service delivery are a concrete focus of action that can be emphasized while efforts to reduce poverty and increase access to education continue.

Poor access to essential medicines

Exacerbating these implementation challenges is the unpredictable availability of essential medicines in many developing regions [67]. Inconsistency of supplies leads to high levels of frustration among healthcare providers who need working diagnostic equipment, operating theaters with adequate lighting and essential medicines to manage patients' pain [51]. Recent surveys in 30 developing countries found that only a third of essential medicines are available in the public sector and 63% are available in the private sector [67]. In surveyed countries, private sector patients were paying over 650% more than the international reference price for essential medicines, while public sector patients were paying approximately 250% over the reference price [67].

In maternal health, poor access to life-saving drugs often leads directly to death. Generic oxytocin, misoprostol, mifepristone, magnesium sulfate and antibiotics are still not available in many parts of the world, nor are they used optimally owing to problems in the supply chain or storage [31,73,74]. While funding shortfalls and policy restrictions are often beyond healthcare providers' scope of control, frequently running out of stock may also be caused by poor management of logistics, inadequate communications or a lack of training and supervision, all of which can be improved at the local level.

Overcoming challenges in developing countries

Despite the myriad challenges that developing countries face in their efforts to reduce rates of maternal mortality, evidence from a variety of low-resource settings [50,75–77] suggests that, in a politically supportive environment, dramatic declines in maternal deaths can be achieved through simple, cost-effective interventions [78].

Sri Lanka & Malaysia: targeting interventions to reach the poor & underserved

Between 1930 and 1995, Malaysia and Sri Lanka succeeded, via similar means, in reducing their MMRs by half every 6–12 years [5,79] down to under 50 per 100,000 live-births by 1995. In the 1930s, Malaysia, despite boasting a relatively strong economy, and Sri Lanka, a low-income country with exceptionally high levels of female literacy, were both plagued with MMRs of over 500 per 100,000 live-births and over 2000 per 100,000 live-births, respectively [79]. Understanding the devastating effect of the poor state of maternal health on national growth and progress, both countries implemented comprehensive national strategies to reduce maternal mortality. Four key components contributed to the success of both national programs: comprehensive strengthening of human development programs (i.e., infrastructure, education, sanitation and health systems) – specifically in poor and underserved areas; modest but significant investments in improved maternal health services; expanded roles of and access to professional nurse–midwives; and ongoing political support and commitment [41,79]. Notably, concurrent with maternal mortality decline during this period, Sri Lanka also decreased its TFR from 5 to 2.2 live-births per woman of reproductive age and Malaysia from 6.3 to 3.4 live-births per woman of reproductive age [204].

Aided by favorable political climates and active political bodies committed to reducing maternal mortality in both countries, modest investments in roads, rural health clinics and human resources enabled the governments of Sri Lanka and Malaysia to remove the majority of financial barriers in order to care for the rural poor and other hard-to-reach, underprivileged groups. Access to basic health services rapidly increased. Other human development programs, such as adult education initiatives and maternal health campaigns, led to improved knowledge and understanding of the importance of skilled attendance at birth. Notably, neither country spent more than 3% of its gross domestic product on health – markedly lower than other countries of a similar economic standing.

Against this backdrop of systems strengthening, both Sri Lanka and Malaysia embarked on unique and rigorous professional training programs. Both programs equipped nurse–midwives to handle basic complications in child birth, linked them to the formal healthcare system and encouraged collaboration with hospitals

and health-centers. With the benefit of a newly increased status within communities, freshly trained nurse–midwives were deployed in rural areas. Within a decade of the programs' inception, both countries achieved an increase from less than 1% to over 40% skilled attendance at birth. Through additional investments in health-systems strengthening (e.g., improving hospital infrastructure, increasing training in maternal health and EmOC and creating professional links between rural nurse–midwives and the formal health systems) strong systems were in place when needed. As the utilization of these services increased, and maternal mortality demonstrated rapid declines, the governments of Sri Lanka and Malaysia were able to focus on quality, accountability and collaboration across sectors [50,79].

Honduras: making maternal health a political priority

In just 7 years, from 1990 to 1997, the MMR in Honduras declined from 182 to 108 per 100,000 live-births [75]. Few other countries have ever reported such a rapid decline in such a short period of time; therefore, the Honduran model deserves a closer examination. Throughout the 1970s and 1980s, with international donor support, the Honduran government had prioritized rural health programs and maternal health. A 1983 study based on hospital records alone reported an MMR of 50 per 100,000 live-births, confirming for the government that maternal mortality was not a widespread problem in Honduras. In 1990, the Reproductive Age and Mortality Survey (RAMOS) for Honduras (the gold standard for maternal mortality measurement) reported a MMR of 182 per 100,000 live-births [76]. Stunned by the magnitude of the problem, one prominent public health official undertook the task of publicizing the report and the severity of the issue to government ministers and other prominent politicians and organizations. By the end of the year, the health minister had made the reduction of maternal mortality a national priority [78].

In order to develop an effective solution, the government formed a high-profile, cross-sector working group comprised of civil society leaders, government organizations, international donors and health officials. Recommending a program focused on system-wide strengthening, integration of traditional and formal health systems and health-worker training focused on risks in pregnancy, the Honduran government

harnessed the political momentum of the moment and created unique partnerships with international donors in order to fund training and technical assistance and to strengthen their health-system infrastructure [77,78]. At the same time, the government undertook the task of professionally training thousands of TBAs to identify high-risk women during pregnancy and encourage them to deliver in healthcare facilities, and recognize obstetric emergencies and refer them to hospitals immediately. In addition, by establishing maternity waiting homes (facilities where TBAs could bring high-risk mothers to wait in a comfortable and culturally-appropriate environment for facility delivery) and through joint workshops with clinicians and TBAs, the government encouraged and increased collaboration between two sectors that had, until then, been at odds. National publicity campaigns were conducted to increase public knowledge of maternal mortality and its risk factors. Public–private partnerships were also successful in increasing the uptake of services and reinforcing the ongoing government commitment to reducing maternal deaths in Honduras and improving maternal health overall [76].

The remarkable declines in maternal mortality achieved by Sri Lanka, Malaysia and Honduras at varying stages of those countries' economic development are encouraging. They demonstrate how governments can successfully prioritize and establish an ongoing commitment to the reduction of maternal mortality and how governments can implement cost-effective, nationally appropriate solutions by following through with their political and financial commitments. These models, with some modifications based on circumstance and culture, could be considered for replication by other countries with high MMRs.

Achievable strategies for high mortality, low-resource settings

Shift the political environment

Cohesive, global support for maternal health has been difficult to achieve for a number of reasons, among them being measurement difficulties, relative lack of severity (maternal death is a rare event as compared with many other diseases), disagreement regarding which interventions to prioritize and a fragmented framework for global safe motherhood advocacy [41].

In order to understand the movements' challenges and to promote its success, Shiffman and Smith recommend the consideration of the

following framework comprising the key factors for successful global healthcare priorities: actor power (policy community cohesion, strong leadership and civil society mobilization); ideas (internal agreement by all involved actors on the scope and frame of the issue); political contexts (awareness of and access to policy windows or ‘political opportunities’); and issue characteristics (effective marketing of credible indicators and cost-effective interventions) [41].

Prioritizing cost-effective interventions

In a recent study, Prata *et al.* input country-level data from sub-Saharan Africa into the Mother Baby Package to calculate the relative cost per death averted (per safe motherhood intervention) in three models based on income per capita [80]. In the lowest income countries, cost per death averted was lowest for antenatal care that included misoprostol distribution for PPH prevention during home-based deliveries. Family planning and safe-abortion services saved the most number of lives, followed by antenatal care with misoprostol distribution and finally by facility-based PPH management.

Findings from such studies point to the importance of prioritizing interventions that will address the leading causes of maternal death worldwide (PPH is often followed by unsafe abortion), as well as those that reduce the incidence of unintended pregnancies (APPENDIX C) in order to avoid all causes of maternal death. Governments with limited resources can increase the cost-effectiveness of family planning and safe-abortion services by implementing cost-saving strategies, such as the community-based distribution of socially marketed contraception [81]. Furthermore, adding a low-cost, easy to use, effective drug such as misoprostol (for PPH prevention during home-based deliveries) to antenatal care packages may increase the cost-effectiveness of antenatal care while also increasing convenient access to life-saving technologies for women who do not deliver at a health facility.

Task-shifting & primary healthcare

Developing countries facing human resource shortages have consistently found safe motherhood goals such as universal skilled attendance at birth hard to meet (APPENDIX C1). Task-shifting, or the delegation of clinical tasks from higher-level healthcare providers to mid- or lower-level healthcare providers is therefore necessary to increase the coverage of safe motherhood interventions in high-mortality, low-resource settings (Box 2).

Both the Addis Ababa Declaration (2008) and the Kampala Declaration and Agenda for Global Action (2008) publicly support task-shifting agendas (APPENDIX C2) [82,83], and many governments have had great success in training assistant medical officers and other mid-level healthcare providers to perform interventions traditionally carried out by physicians (i.e., cesarean sections) [51,60,84,85]. For example, a comparative study evaluating the outcome of cesareans performed by assistant medical officers (n = 958) and specialists in obstetrics and gynecology (n = 1113) at Maputo Central Hospital in Mozambique found no difference in serious postoperative complications between the two levels of healthcare providers [86].

Other maternal health interventions would also benefit from task-shifting in order to increase coverage; for example, antenatal care can be effectively provided by a lower-level healthcare worker, as long as they have the training, equipment and supplies, along with appropriate supervision by a higher-level healthcare provider [24]. Management of sepsis, typically provided by physicians and mid-level healthcare providers, could be provided by community-based health-workers using preassembled packages of antibiotics [13,87–89]. Socially marketed antibiotic packages have been demonstrated to be effective in neonatal infections. In a study using village health-workers to distribute pre-packaged antibiotics, incidence of neonatal sepsis declined from 16.6% in study sites to 2.8% ($p \leq 0.01$) [87].

Increasing the care available at primary healthcare facilities will lead to increases in access; for example, the treatment of uncomplicated abortions or miscarriage at primary healthcare facilities would increase access to safe postabortion care. Furthermore, shifting from surgical to medication-based abortion could significantly increase access to safe abortion and postabortion care. The benefits of shifting to medication-based abortion include increasing the number and distribution of healthcare providers, reduced training requirements, a lower risk of surgical and anesthesia-related complications and reduced costs to the healthcare system [90,91].

Postpartum hemorrhage is usually treated in tertiary hospital settings where skilled healthcare providers, iv. fluid replacement and blood transfusion are readily available. Training primary healthcare workers to use misoprostol in order to prevent PPH in situations where oxytocin is not available could greatly reduce mortality caused by hemorrhage [73,92].

In postpartum care, periodic visits by health-workers to prevent deaths owing to excess bleeding or sepsis are simple interventions that need greater emphasis. Postpartum provision of family planning methods at the community level is essential to enable women to achieve ideal birth-spacing. In addition to condom and oral pill provision, postpartum provision of injectable contraception has proven to be effective [93,94]. Provision of injectables has been traditionally restricted to skilled healthcare providers; however, pilot studies in Uganda, Madagascar and Ethiopia have successfully trained lower-level healthcare providers to administer injectables [93,94]. Finally, postpartum advice need not only be given by healthcare professionals and community-based healthcare providers, but can be imparted by family members as well [40].

Improved health-management information systems

Public and private sector program planners need cause-specific mortality data in order to adequately prioritize safe motherhood efforts. Reliable morbidity and mortality levels and differentials are key to developing evidence-based policies in healthcare. Data generated by health information and vital registration systems can provide such estimates, but most countries in sub-Saharan Africa do not have functioning vital registries, and their health-information systems often produce estimates limited to those who have been cared for at healthcare facilities. Tracking progress is complicated, since maternal mortality estimates are usually available only at the national level, so even if a safe motherhood intervention is successful in a specific area, its true impact may not be detected [95].

Existing sources of data regarding maternal mortality include vital registration, health-facility statistics, census, population-based approaches and verbal autopsy. However, it is recognized that none of the aforementioned approaches alone can provide accurate and complete data for maternal mortality estimation at national or regional levels.

Strengthening vital registration systems is a key priority of the WHO [96]. In situations where a complete registry is unavailable, an innovative method, such as a community-based sentinel surveillance system using complete vital registration and verbal autopsy for maternal deaths, would be ideal. Verbal autopsy is an important tool, since it can be used with a variety of data sources and is especially useful for elucidating causes of death [97–99]. Since

physicians are scarce in developing countries, especially in rural locations where registries are barely functional, verbal autopsy, which relies on mid-level healthcare providers (e.g., nurses and medical officers), would be more practical [100]. Such a mixed-methods approach would produce accurate measurement of vital events, including estimates of maternal mortality and distribution by causes of death in low-resource settings. The generation of reliable, continuously available, real-time demographic indicators would enable evidence-based prioritization of healthcare interventions and subsequent improved planning for resource allocation, monitoring and evaluation.

Conclusion

The world has witnessed significant changes in the topic of ‘what should be done’ to decrease maternal mortality – from a focus on communities with training of TBAs to an intervention-focused approach. The change in focus is sometimes based less upon evidence and more upon politics; for example, while the focus on community-based programs has been largely neglected, a recent analysis of randomized controlled trials of community-based interventions concluded that those interventions can bring about reductions in maternal mortality [53]. In a recent article published in *The Lancet* as part of the *Maternal Survival Series*, the authors argue that intrapartum care strategies should be the ones to be prioritized, despite the complexity of interactions between an enormous diversity of country contexts and determinants of maternal health [13]. Others also suggest that strategies to reduce maternal mortality in resource-poor settings should focus on reducing the risk-pool by decreasing fertility through contraceptive use and the provision of safe abortion, followed by a focus on the main cause of maternal mortality: PPH [80]. Adding to the discussion concerning setting priority strategies in maternal healthcare is the fact that the field has been chronically underfunded [101].

The experience of pregnancy is an experience that is feared among many women in developing regions of the world. A lack of access to

Box 2. Advantages of task-shifting.

“[Task-shifting] increases access to life-saving treatment; improves the workforce skills mix and health-system efficiency; enhances the role of the community; has many cost advantages and reduces attrition and international brain drain.”

Reproduced from [62].

appropriate medical interventions (including healthcare personnel and medical facilities) and a lack of knowledge regarding when to intervene (either in recognizing that there is a problem, deciding to seek intervention or actually receiving care) are two important challenges to increasing access to maternal health interventions.

Although achievement of significant maternal mortality decline may seem like an insurmountable goal, we have the knowledge and tools necessary to succeed in saving the lives of hundreds

of thousands of women each year. The success of current and future program implementation will rely heavily upon the level of political commitment and achieving wide-scale coverage with the most cost-effective interventions.

Future perspective

In countries where maternal mortality is maintained at very high levels, such as sub-Saharan Africa, a more careful analysis of current interventions and their successes and challenges in

Executive summary

Levels, trends & causes of maternal mortality

- Every year, approximately 500,000 women die of maternal causes worldwide.
- Approximately 99% of these deaths occur in developing countries.
- Sub-Saharan Africa accounts for 50% of the maternal death burden, followed by Asia with 45%.
- Approximately 70–80% of maternal deaths are due to direct obstetric causes.

Historical perspective

- In the 1990s, population age-structure and parity changes occurred to reduce maternal mortality in the USA and in the Netherlands.
- Reduction of maternal mortality in northwestern Europe is attributed primarily to skilled attendance in childbirth.
- From the 1930s to the 1960s in the West, major advances in medical technologies led to a reduction in maternal mortality.

Priority interventions to reduce maternal mortality

- Prior to pregnancy, key interventions to reduce maternal mortality include family planning, sexually transmitted infection/HIV prevention and comprehensive abortion care.
- During labor, delivery and the postpartum period, key interventions include the prevention or management of postpartum hemorrhage, sepsis, hypertensive disorders of pregnancy and obstructed or prolonged labor.

Challenges in implementation

- Debate over priority interventions has slowed the pace of implementation.
- Lack of skilled providers prevents good coverage and scale-up of interventions to a nationwide scale.
- Training opportunities are insufficient, especially for mid- & lower-level providers.
- High fertility keeps women at higher risk for morbidities and mortality.
- Access to essential medicines is sorely lacking.

Overcoming challenges in developing countries

- Successful programs may be replicable in developing countries with high maternal mortality, if adapted to specific cultural contexts.
- Honduras, Sri Lanka and Malaysia have achieved impressive declines in maternal mortality by implementing simple, cost-effective interventions within politically supportive environments.

Achievable strategies for high-mortality, low-resource settings

- Analysis of the political context is essential to effectively tailor safe motherhood advocacy to specific national contexts.
- Mobilization of multisector alliances has proven effective in reducing maternal mortality ratio.
- Cost-effectiveness studies can demonstrate which interventions have the highest potential impact on maternal mortality.
- Task-shifting is an important strategy to increase access to key interventions.
- Evidence-based prevention strategies require cause-specific mortality data, which can be gained by improving data collection and by using verbal autopsy.

Conclusion

- Lack of access to appropriate interventions and lack of knowledge regarding when to intervene are two underestimated hurdles in maternal health.
- The knowledge and tools exist to reduce maternal mortality, but sufficient political commitment will be critical in scaling up the most promising and cost-effective interventions.

Future perspective

- More careful, cohesive analyses of the challenges and successes of current safe motherhood interventions are necessary.
- Feasibility and scale are essential considerations in interventions designed to reduce maternal mortality.
- Community-level access to life-saving interventions is imperative.

implementation thus far is required. There is a lack of cohesion among safe motherhood advocates, which is not so much related to ‘what works’, but mainly relates to what should be prioritized (taking feasibility into account) and provided on a large scale for maximum impact.

The only way to ensure adequate coverage of interventions to reduce maternal mortality is to ensure that life-saving products and services are offered not just in a clinic setting, but also where women feel comfortable at the community-level [24,54]. This includes family planning, ANC, abortion and PAC, home-based interventions to prevent PPH and sepsis and postpartum care. Women’s socioeconomic status is clearly a major factor in why some women seek care and others do not. Services must come to them. If cost is not the primary barrier, mobility may prevent healthcare utilization, such as when it

is not customary for a woman to travel unaccompanied beyond her village. Convenience is a factor that is often ignored when planning programs. Existing evidence demonstrates that service utilization is highly related to how services are being provided from one’s home. The further someone is from the services, the less likely it is that those services will be utilized.

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Appendices

Appendix A. The Mother Baby Package

The Mother Baby Package (MBP) is a package of interventions prescribed by the WHO, based on existing, large-scale, published studies of program-effectiveness, which is technically and economically feasible in developing countries [301]. The MBP consists of 18 essential safe motherhood interventions that have the goal of reducing neonatal and maternal mortality and morbidities in resource-scarce settings. Application of the interventions for the mother and newborn is dependent upon the stage of pregnancy (i.e., prepregnancy, during pregnancy, labor and delivery and postpartum) and the ability of healthcare staff to implement the interventions given the level of the healthcare facility (e.g., primary health post, district health center or hospital) and available resources for the interventions. Although the MBP outlines a set of 18 interventions that will reduce maternal mortality, it is not considered to be a prescription for every country. The goal of the package is to provide guidelines that individual nations can use to prioritize their safe motherhood efforts given the local context, including coverage goals. Specifically, the MBP considers the following interventions essential for decreasing maternal and neonatal mortality in resource-poor settings: antenatal care (i.e., treatment of sexually transmitted infections and severe anemia), family planning (i.e., condoms,

injectable contraceptives, implants, IUDs and oral contraceptive pills [OCPs] or sterilization), management of abortion complications, hemorrhage, sepsis or eclampsia, clean and safe delivery services (for normal atraumatic delivery and prolonged/obstructed labor) and postpartum care (including for neonatal complications).

Appendix B. Priority interventions to reduce maternal mortality

B1. Contraceptive methods

The most effective methods of female sterilization have a 10-year cumulative pregnancy rate of 7.5 per 1000 procedures. The failure rates of vasectomy is less than 1%. Of the contraceptives that contain only progestin (including Norplant™, Depo Provera™, and progestin-only IUDs, the failure rate is 0.3–1.0 pregnancies during 1 year of use [302]. IUDs made of copper are also highly effective. Out of 100 women who use copper-bearing IUDs (Cu-IUDs), only one will become pregnant in the first year of use [302]. OCP and condoms are considered highly effective methods when used correctly and consistently. However, with typical use, the failure rate for OCPs is just under 10%, and with typical condom use, approximately 3–14% of women become pregnant annually [302]. For emergency contraception, a regimen of 25–50 mg mifepristone has been demonstrated to be the most effective regimen, but a lower dose of the same drug (<25 mg)

can be nearly as effective (risk ratio: 2.01; 95% CI: 1.27–3.17). In the absence of mifepristone, a single dose of 1.5 mg levonorgestrel is recommended, which reduces the risk of pregnancy by over 23%. Where levonorgestrel is unavailable, the Yuzpe regimen (combined estrogen/progesterone tablets), although lower in effectiveness, can be used [303]. There are limited data available comparing the effectiveness of Cu-IUD insertion versus mifepristone for emergency contraception. A 2008 review found one small trial that compared the two; this trial recorded only one pregnancy in the mifepristone group [303]. Data from nonrandomized studies in China found that postabortion insertion of Cu-IUDs is effective, with a failure rate of only 0.09%. An important potential benefit of the IUD in the Chinese context was that 80% of women chose to keep their IUD in place for long-term contraception [303].

B2. Antenatal care

Antenatal care “should consist of at least four visits of 20 minutes each and includes anemia screening, tetanus vaccination, malaria prophylaxis (where appropriate), diagnostic tests, treatment for sexually transmitted infections and severe anemia (including iron and folate supplementation), advice on diet, rest and delivery care, blood pressure measurements to check for pre-eclampsia, immunization against tetanus, taking of obstetric history, and completion of a maternal record for each woman so that signs of complications can be identified and appropriate actions taken” [301].

B3. Antepartum hemorrhage

According to the WHO, antepartum hemorrhage (APH) is defined as “severe bleeding before and during labor often due to placenta praevia or placental abruption” [304]. At presentation with APH, if considered fatal, a woman has an estimated 12 h until death [304,305]. In up to 10% of placenta previa cases, there is coexisting placental abruption [306]. The least common cause of APH is uterine rupture [307,308]. It is estimated that in 40% of APH cases, no cause can be identified [309]. In general, risk factors for maternal hemorrhage are primigravidity, multiparity (>4), fibroids and anemia.

B4. Puerperal sepsis

According to the WHO, puerperal sepsis is defined as “a temperature of 38°C or higher more than 24 h after delivery (with at least two readings, as labour alone can cause some fever) and any one of the following signs and symptoms:

purulent (containing pus) vaginal discharge, tender uterus, uterus not well contracted, history of heavy vaginal bleeding (rule out malaria)” [304]. Women who suffer from puerperal sepsis and do not die are often left with debilitating morbidities, including maternal tetanus, chronic pelvic pain, pelvic inflammatory disease, bilateral tubal occlusion, dysmenorrhoea, menorrhagia and/or infertility [301,310,311]. The newborn may also suffer from neonatal sepsis if maternal infection is not treated [305].

B5. Eclampsia

According to the WHO, severe pre-eclampsia is defined as “a diastolic blood pressure >110 mmHg or proteinuria >3 after 20 weeks gestation. Signs and symptoms include headache, hyperreflexia, blurred vision, oliguria, epigastric pain, pulmonary oedema. Women with eclampsia may also present with signs and symptoms similar to severe pre-eclampsia” [304]. Eclampsia is suspected when a woman presents with one or more of the following symptoms: severe headache, generalized edema, blurring of vision and/or convulsions (seizures in the CNS) [301]. The newborn may also suffer from birth asphyxia, stillbirth or low birth weight if not rapidly delivered once eclampsia or unresolved pre-eclampsia occurs [301,305].

B5.1. Labetalol for hypertension

Since FDA approval in 1997, labetalol has been considered the first-line therapy for treating hypertension in the USA [312]. It has also been used in the UK and other locations around the world [313]. Labetalol works quickly (dependent upon dosage used per individual) to decrease blood pressure, but does not cause reflex tachycardia or reduced heart rate, nor does it cause harm to the fetus, unlike other commonly used antihypertensives, such as hydralazine. Finally, labetalol, if used during pregnancy, does not decrease uteroplacental blood flow [314]. Since labetalol is in tablet form, it does not require the skills necessary for administering magnesium sulphate, the drug currently used to treat eclampsia.

B6. Obstructed/prolonged labor

Prolonged and/or obstructed labor are most frequently caused by what is called ‘cephalo–pelvic disproportion,’ which causes mechanical arrest during the progression of fetal descent at labor. In prolonged labor, the fetal head is engaged and fetal heart sounds and presentation are normal but labor has lasted for more than 12 h. In obstructed labor, the fetal head is not engaged, presentation is abnormal and fetal heart sounds

are either too slow or too fast [310]. If death does not occur after prolonged or obstructed labor, severe morbidities that can result include obstetric fistulae, urinary incontinence, uterine rupture, uterine prolapse, amnionitis and sepsis. Infant death is possible when prolonged and/or obstructed labor are not managed in a timely manner. Fetal death or severe morbidities in cases of prolonged/obstructed labor are often a result of neonatal sepsis, asphyxia (leading to stillbirth) or birth trauma, including brain damage or other handicaps [301,310].

B6.1. Partograph for monitoring labor progression

The partograph is a tool that can be used to follow labor progression. By plotting the progression against time of cervical dilation, duration of labor in hours, fetal descent and uterine contractions, the graphing tool assists birthing attendants to determine if and when intervention is necessary. The graph can also be used to monitor other conditions, including pulse rate, blood pressure, temperature, urine, medications, iv. fluids, oxytocin administration, fetal heart rate, membranes and liquor (the color, lack of or insufficient amount of amniotic fluid, including the presence of meconium, are used to indicate types of fetal distress) and molding of the fetal skull [315–317].

B7. Postpartum hemorrhage

The WHO classifies the following conditions as postpartum hemorrhage: “bleeding that requires treatment (e.g., provision of intravenous fluids, uterotonic drugs or blood), retained placenta, severe bleeding from lacerations (vaginal or cervical), more than one pad soaked in blood in 5 min, vaginal bleeding in excess of 500mL after childbirth” [304]. Severe PPH is often defined as greater than or equal to 1000 ml blood loss after delivery [310]. The reported incidence and prevalence of PPH varies greatly depending on the availability of emergency obstetric services and accurate maternal death records for the entire population. According to the MBP, the percentage of births requiring management of postpartum hemorrhage is 5.0% [301]. A more recent WHO analysis of the causes of maternal deaths by Khan *et al.* found that mortality from maternal hemorrhage ranges from a pooled percentage of 20.8–33.9% in developing regions (Africa, Asia and Latin America/Caribbean) [318]. Management of PPH may include a variety of surgical procedures, such as suture compression

techniques, intrauterine compression or less conservative techniques such as stepwise devascularization [319–321]. If all interventions have failed, sub/total hysterectomy is a final option in order to save a woman’s life [322].

Appendix C. Achievable strategies for high-mortality, low-resource settings

C1. Access to obstetric care services

According to the latest available Demographic and Health Surveys, the percentage of met need for skilled birth attendants in sub-Saharan Africa ranges from 6.3% (Ethiopia) to 85.1% (Congo-Brazzaville); in South/South East Asia from 20.8% (Bangladesh) to 74.9% (Indonesia); and in Latin America/Caribbean from 27.4% (Haiti) to 95.0% (Dominican Republic). The percentage of individuals who had a facility-based delivery during their last pregnancy in sub-Saharan Africa ranges from 5.8% (Ethiopia) to 82.6% (Congo-Brazzaville); in South/South East Asia from 15.8% (Bangladesh) to 48.4% (Indonesia); and in Latin America/Caribbean from 22.7% (Haiti) to 97.7% (Dominican Republic). The percentage of met need for cesarean sections in sub-Saharan Africa ranged from 0.4% (Chad) to 13.4% (Nambia) and in South/South East Asia 2.2% (Cambodia) to 9.0% (India). In Latin America/Caribbean, the provision of cesareans ranges from significant unmet need, where only 3.4% of the population in Haiti are being delivered by cesarean section, to excessive use of cesareans, where 44.3% of the population in the Dominican Republic are being delivered by cesarean section [401].

C2. Policy development in task-shifting

In January of 2008, the *International Conference on Task Shifting* in Addis Ababa, Ethiopia convened and created the Addis Ababa Declaration to address the human resource shortage crisis that is impeding progress in developing countries towards meeting the Millennium Development Goals, including Goal 5, to improve maternal health. The declaration recognizes that “reorganization and decentralization of health services, including task-shifting, can help to address the current shortages of health workers, if implemented alongside a broad range of other strategies that are designed to address other aspects of the human resources for health crisis” [323].

In March of 2008, the *First Global Forum on Human Resources for Health* concluded with The Kampala Declaration and Agenda for Global

Action which recognized the importance of scaling-up mid-level provider training to increase access to all forms of health-care [324]. The declaration calls upon “Governments to determine the appropriate health workforce skill mix and to

institute coordinated policies, including through public private partnerships, for an immediate, massive scale-up of community and mid-level health workers, while also addressing the need for more highly trained and specialized staff” [324].

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