Averting Maternal Death and Disability

The evidence for emergency obstetric care

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Abstract

Purpose: We searched for evidence for the effectiveness of emergency obstetric care (EmOC) interventions in reducing maternal mortality primarily in developing countries. Methods: We reviewed population-based studies with maternal mortality as the outcome variable and ranked them according to the system for ranking the quality of evidence and strength of recommendations developed by the US Preventive Services Task Force. A systematic search of published literature was conducted for this review, including searches of Medline, PubMed, Cochrane Database of Systematic Reviews, the Cochrane Pregnancy and Childbirth Database and the Cochrane Controlled Trials Register. Results: The strength of the evidence is high in several studies with a design that places them in the second and third tier in the quality of evidence ranking system. No studies were found that are experimental in design that would give them a top ranking, due to the measurement challenges associated with maternal mortality, although many of the specific individual clinical interventions that comprise EmOC have been evaluated through experimental design. There is strong evidence based on studies, using quasi-experimental, observational and ecological designs, to support the contention that EmOC must be a critical component of any program to reduce maternal mortality.

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1. Introduction

The death of women during pregnancy, childbirth or in the postpartum period was once a common occurrence worldwide. Today, 99% of maternal deaths occur in the developing world, reflecting the greatest disparity between wealthy and resource-poor countries of any health indicator [1].

The vast majority of maternal deaths are due to direct obstetric complications—hemorrhage, sepsis, complications of abortion, hypertensive disorders of pregnancy, prolonged/obstructed labor, ruptured uterus and ectopic pregnancy [2]. These complications occur even in well-nourished, well-educated women [3] receiving adequate prenatal care [4] and generally cannot be predicted [5—9]. While some strides have been made in the prevention of some of the direct obstetric complications, many cannot be prevented even in the best of circumstances. Exceptions include reduction in postpartum hemorrhage through active management of third stage of labor [8,10,11], reduction in complications of abortion through provision of safe abortion and family planning services and reduction in postpartum sepsis through attention to infection prevention during delivery, especially avoidance of frequent vaginal exams during labor [12,13].

Low maternal mortality ratios (MMR) in the West today are due, in large part, to the fact that obstetric complications are identified and treated promptly in the context of a functioning health care system. Programs to reduce maternal mortality in resource-poor settings, where ratios are high, must be able to treat these complications.

A package of medical interventions required to treat the seven major direct obstetric complications was identified by WHO, UNICEF and UNFPA [14]. This package of services is known collectively as emergency obstetric care (EmOC). Facilities that provide the following medical interventions (known as “signal functions”) are called Basic EmOC facilities: administration of parenteral antibiotics, oxytocic drugs and anticonvulsants, as well as manual removal of placenta, removal of retained products and assisted vaginal delivery. Comprehensive EmOC facilities perform all the basic EmOC signal functions as well as perform surgery (Cesarean section) and provide blood transfusion.

The individual clinical components of the EmOC package (surgery, antibiotic treatment, treatment of eclampsia, blood transfusion, etc.) are all standard medical practices dating to the 1930s, so basic safety and effectiveness are not at issue. However, improvements are still being made in protocols for treating specific obstetric complications (techniques, indications, drugs, etc.). These changes are subjected to randomized controlled trials (RCTs). For example, there is now strong evidence that magnesium sulfate is more effective than diazepam in the treatment of eclampsia and severe pre-eclampsia, [15—17] that use of vacuum extraction rather than forceps for assisted vaginal delivery reduces maternal and neonatal morbidity [18], and that prophylactic use of antibiotics reduces the incidence of maternal infection after Cesarean section [19]. Similarly, there have been rigorous clinical studies of ways to reduce bleeding after delivery.[20—22].

Emergency obstetric care is one of two relatively recent strategies promoted for the reduction of maternal mortality in developing countries, the other being delivery by a skilled birth attendant [23]. These two strategies overlap in many important ways, and the evidence base for them also overlaps significantly, as will be discussed in the following sections. First of all, virtually all treatment of obstetric complications is carried out by a provider who would fall squarely within the definition of a “skilled attendant,” i.e., a physician, nurse or midwife “trained to proficiency in the skills needed to manage normal (uncomplicated) pregnancies, childbirth and the immediate postnatal period, and in the identification, management and referral of complications in women and newborns” [24]. Secondly, EmOC facilities provide vitally needed back-up for skilled attendants working in communities in resource-poor settings. For example, because the training and experience of many skilled attendants, and the setting where they attend deliveries (homes and lower level health facilities), allow them to do little more than manage normal deliveries, the ability to refer a complicated case to an EmOC facility may be the difference between life and death during obstetric emergencies. Recognition of the interconnectedness between the skilled attendant and the “enabling environment” in which he or she performs has led to a concept of “skilled care” that, in essence, joins the skilled attendant strategy with the EmOC strategy. (It should be noted that most but not all obstetric complications occur during or immediately after delivery, at a time when the woman is, or should be, under the observation of the skilled attendant. Obstetric emergencies also occur in early pregnancy, such as ectopic pregnancy or complications of abortion,

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1 The number of deaths of women from causes related to pregnancy and childbirth per 100,000 live births.
or 1–2 weeks postpartum as with postpartum sepsis or secondary postpartum hemorrhage). Finally, all countries with low MMR have both high proportion of births attended by a skilled attendant (whether in hospitals such as in the United States or at home as in the Netherlands), and near universal access to high-quality EmOC in case of obstetric emergencies.

Nevertheless, there are significant differences between the EmOC strategy and the skilled attendant strategy, mostly in the timing of the phasing in of the two strategies in resource-poor settings. The reality in countries with high MMR is that many women, especially in rural areas, are not giving birth with a skilled attendant, and that there are often no nearby EmOC facilities available for women with obstetric emergencies. The question, then, for the country’s leaders is whether to give priority to more skilled attendants or to EmOC.

What evidence exists, then, that EmOC prevents maternal deaths in developing countries? Evidence, as understood today in medicine and in public health, refers primarily to results of rigorously conducted clinical and field studies. Evidence based upon experimental studies (such as randomized clinical trials [RCT] or randomized field trials) is considered more persuasive, generally, than evidence based on quasi-experimental (non-randomized) studies, observational studies (cohort studies, case-control studies or ecological studies), or studies undertaken without a control group (including program evaluations) [25,26].

In this paper, studies of EmOC interventions with maternal mortality as the outcome variable were ranked according to the system for evaluating the quality of evidence and strength of recommendations developed by the US Preventive Services Task Force [27]. The types of evidence and the grade accorded to each are shown in the box below. The highest quality of evidence or the ‘gold standard’ in this grading system is the randomized control trial. Within each grade, the recommendation made by the researchers is ranked on a scale from A (good evidence to support the intervention) to E (good evidence against the intervention).

<table>
<thead>
<tr>
<th>Grade</th>
<th>Type of evidence</th>
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<tbody>
<tr>
<td>Grade I</td>
<td>randomized controlled trial</td>
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<tr>
<td>Grade II-1</td>
<td>controlled trial without randomization</td>
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<tr>
<td>Grade II-2</td>
<td>cohort or case-control studies</td>
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<tr>
<td>Grade II-3</td>
<td>multiple time series with or without the intervention</td>
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<tr>
<td>Grade III</td>
<td>descriptive studies based on clinical experience or reports of expert committees</td>
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A systematic search of published literature was conducted for this review. Medline was searched for all articles published from 1980 to 2003, (the Safe Motherhood Initiative began in 1987). Searches were done on Medline for keywords “maternal death,” “maternal mortality” and “emergency obstetric care.” Extensive searches were also conducted using PubMed to compare the results with the articles found on Medline. Articles from the Cochrane Database of Systematic Reviews, the Cochrane Pregnancy and Childbirth Database, and the Cochrane Controlled Trials Register were also reviewed. Studies from over 80 countries were included in the systematic review, although only population-based studies that use maternal mortality as the outcome variable (as opposed to studies that use a process indicator or deaths due to only one cause of maternal mortality) and have some information about maternity care services, including EmOC service availability, are discussed at length. Of the 2861 articles reviewed, 8 fit the selection criteria and were examined for this paper. The following sections review studies of similar design, and a summary chart ranking existing evidence for EmOC is provided at the end of the paper, and the interpretation of the evidence and what it implies for public health decision-making for maternal mortality reduction in developing countries is discussed.

2. Evidence for effectiveness of the EmOC strategy

2.1. Experimental and quasi-experimental evidence

Because of measurement problems, it is exceedingly difficult to evaluate whether EmOC reduces maternal mortality at the population level using experimental design methodology. Randomized field trials of complex reproductive health interventions have been successfully undertaken in developing countries [28,29] but studies looking at maternal mortality as the outcome variable face unique challenges relating to sample size.

Even where maternal deaths are the leading cause of mortality among women of reproductive age, they are still rare events. Therefore, the number of pregnant women who have to be followed in a community trial is very large, making these studies unusually expensive and challenging to implement. To address the sample size problems, investigators must either lengthen the period of study, or broaden the geographic area covered in
the study and both of these measures add difficulty in interpretation of study results.

Despite these methodological complexities and cost barriers, one quasi-experimental study comparing models of obstetric care service provision in field settings was undertaken in South Asia [30,31].

In Matlab, Bangladesh, an ambitious series of community trials of various health interventions has been conducted since 1960. In 1987, a community-based maternity care project was added to one part of a pre-existing MCH/FP program (Intervention Area), while areas to the north and south received no special services but were kept under surveillance [30,31]. Midwives trained in both normal deliveries and obstetric emergencies were posted to each of the two health centers in the Intervention Area, and a maternity-care clinic was established in Matlab. Emergencies beyond the capacity of the midwives were actively referred to the Matlab maternity clinic (which provided Basic EmOC services) or to the government’s district hospital where Comprehensive EmOC services were available. The midwives were encouraged to accompany women to these facilities in case of an emergency, and transportation was facilitated by 24-h access to a boat and boatman, and an ambulance to refer women from Matlab to the district hospital [31].

Maternal mortality in this Intervention Area was compared with maternal mortality in the three other parts of the Matlab study area: the area of the MCH/FP program not augmented with maternity services (Control Area), and two areas in which only government services were available, one to the south (South Comparison Area) and one to the north (North Comparison Area). The North Comparison Area had poor access to EmOC (up to 4 h travel time to a governmental hospital), while the South Comparison Area had good access (less than 2 h to a governmental hospital providing emergency obstetric care).

As Fig. 1 shows, compared to 1976—1986, mortality due to direct obstetric complications in the Intervention Area in 1987—1989 was reduced by nearly 50%. No such decline was seen in the Control Area [31]. However, maternal mortality also declined by about the same amount in the South Comparison Area, apparently due to the close proximity to the hospital in the south, despite the lack of the specially trained midwives. The one common feature of the two areas where direct obstetric mortality declined is access to emergency obstetric care. In the South Comparison Area, a comprehensive EmOC facility was within 2 h travel time to women living in the area. In the Intervention Area, a basic EmOC facility was available for emergencies 24 h a day, access to this facility was improved through the availability of a speed boat, and access to a district hospital by ambulance was available from the Matlab clinic when blood or surgery was required.

2.2. Observational studies

A cohort study in rural India (Ahmednagar District, Maharashtra State) documented obstetric outcomes, and the patterns and costs of care for women living in 25 villages surrounding the town of Jamkhed, the site of The Comprehensive Rural Health Project [32]. Among other health and development interventions, this project runs a hospital that admits 4000—5000 patients a year and has trained Village Health Workers (VHW) who provide basic health education and clinical service, including assistance at home deliveries, and recognition and referral of complications. The VHWs identify and follow all pregnant women in their villages and record the outcome, place of delivery and any complications, even for those women who leave the village to deliver elsewhere, such as in the maternal family home. In addition to the project hospital, which provides EmOC, there are several private clinics, and two government hospitals providing EmOC located farther away (2 h by car), but within reach of some of the villages in the study area. For this study, information recorded on 2905 pregnancies for the period 1 January 1996 to 1 July 1999 from the project’s VHWs’ record books was reviewed.

A total of 2861 pregnancies went beyond 24 weeks. The vast majority of deliveries (85%) took place at home, mostly attended by a family member. Twenty three percent of the home births
were attended by VHWs, and 4% by another cadre of birth attendant (private physician, government health worker or trained traditional birth attendant). Of the 15% of deliveries that occurred in a hospital or clinic, most began at home with a transfer to a facility during labor. Overall, approximately 15% of pregnant women experienced obstetric complications. Women with obstetric complications were more likely to deliver in a hospital or private clinic (79%), a situation the authors attribute to the population’s awareness of the signs of obstetric complications and willingness to self-refer for care. The rate of Cesarean delivery (at the project hospital or government hospitals) was 2% of all deliveries in the population. Only two maternal deaths were recorded in the cohort (one in a home delivery and one in hospital, both due to hemorrhage), giving an MMR of 70 per 100,000 with very wide confidence intervals due to the small numbers. The authors estimated with 95% confidence that the MMR in this population was below 250 per 100,000, half of the MMR of India as a whole. The estimated per capita cost of the obstetric service provided was low ($0.24 per capita per year or $0.83 per woman of childbearing age). The cost was kept low because 85% of women deliver at home and self-selection for obstetric care was good. This study is unusual in that obstetric complications are treated in EmOC facilities in the context of a rural area where home births are the norm.

In a very different setting—rural Guinea-Bissau—the distance to a hospital was, as in Matlab, one of the strongest predictors of maternal mortality [33]. Of 10,931 prospectively registered pregnancies in a 6-year cohort study, 85 resulted in maternal death. In addition to demographic variables and 12 factors considered to be high-risk criteria in the Guinean antenatal care card, the study gathered information on four factors relating to the availability and use of the health system—place of birth, presence of a health post in the village, distance to health center and distance to hospital. Maternal death was most strongly associated with increased distance (6–25 km compared with 0–5 km) from a hospital. Distance from a hospital of greater than 25 km further increased the odds of maternal death. Neither presence of a village health post nor proximity to a health center was predictive. In this nationally representative study (20 clusters of 100 women were randomly selected from five of eight regions in the country), over 92% of the study population lived more than 5 km away from a hospital. Thus, most women in the study were at increased risk of maternal mortality due to lack of access to a hospital. Of all the risk factors used to screen for complications during antenatal care, only twin birth was predictive of maternal death. Women were also more likely to die if the pregnancy ended in stillbirth. The authors attribute these associations to serious maternal pathology.

While these two studies were undertaken in primarily rural populations, the next study looks at maternal mortality in an urban population. A prospective cohort study in one district of Bamako, the capital city of Mali, demonstrates that access to maternity care is not sufficient if this care is not of good quality [34]. The study followed all pregnancies enrolled over a 3-year period from the identification of the pregnancy through 1 year postpartum. The MMR of 327 per 100,000 is consistent with data from other urban areas of West Africa. Almost 90% of women in the cohort delivered in a maternity hospital, and all had easy access to EmOC. Some of the causes of the 15 deaths suggest poor quality care. For example, one woman died of hemorrhage following ruptured uterus despite delivering in a maternity hospital; two died of sepsis after a Cesarean delivery in a national teaching hospital. The authors conclude that poor quality of care will result in a higher than expected MMR in situations where maternity services (skilled attendants at delivery and EmOC) are available. These findings echo a recently published study from the Dominican Republic, a country with an MMR of over 100 per 100,000 live births [35]. While 97% of women deliver in health facilities, most of which provide EmOC, the quality of care undermines the potential for these services to further reduce the MMR.

2.3. Analysis of maternal mortality trends

Data from 19th and early 20th century Britain show a close ecological correlation between the availability of the medical interventions comprising EmOC and the reduction of maternal mortality. Maternal mortality ratios 150 years ago in Europe and the United States were similar to those in developing countries today [36]. In the mid-19th century, the MMR in England and Wales was 546 maternal deaths per 100,000 births. By 1930, the MMR had declined only to 440, in contrast to huge declines in mortality among adults from other causes and among children during the same period [37]. Cross-national comparisons of maternity care and maternal mortality show that the skill of the maternity care provider, the adherence to antibiotics (after its introduction in the 1880s) and adherence to appropriate protocols for various complications resulted in widely different MMRs, although they were all in the range of high to
extremely high [36]. MMRs in countries where highly trained and supervised professional midwives delivered women primarily in their homes had high MMR, for example, close to 300 in Sweden in 1920. In contrast, the MMR at the same time in the United States was extremely high, over 700, due to the poor skills and interventionist practices of physicians delivering women in hospitals.

Between 1934 and 1950, the MMR in England and Wales fell from 441 to 87 [36]. Similar dramatic declines in maternal mortality were seen in other European countries and in the United States during the same period. This astounding decline in maternal mortality in industrialized countries corresponds precisely to the advent of widespread use of antibiotics for infection (first sulfa drugs in the late 1930s, then penicillin in the late 1940s), blood transfusion for hemorrhage and improved surgical techniques (developed during World War II) [38–41]. Cesarean deliveries, for example, carried a high risk of complications and death before the availability of antibiotics and blood transfusions [36]. This is compelling evidence for a strong association between the ability to treat serious obstetric complications and reduction of maternal mortality, especially since maternal mortality had not declined substantially in the previous 80 years, in marked contrast to the gradual but steady decline in infant mortality over the same period.

While no other period in history witnessed such rapid and sharp declines in MMR as described above, other countries have experienced very significant reductions in MMR over relatively short periods of time. Recently published case studies by the World Bank of the experiences in Sri Lanka and Malaysia in the second half of the 20th century provide lessons of particular relevance to low and middle income countries [42]. In Sri Lanka, the MMR was reduced by half (from 1056 to 486 in the 3-year period from 1947 to 1950 (see Figs. 2 and 3). In Malaysia, the MMR was also halved (from 534 to 282) in the 7-year period from 1950 to 1957. Both countries achieved a second halving of their MMRs in the subsequent 13 years and today have very low levels of maternal mortality.

These dramatic reductions were attributed to step-by-step implementation of interventions appropriate to the evolving capacity of the countries’ health systems. Initial efforts, when mortality was high, focused on availability of services, achieved through an expanding network of appropriately staffed rural health facilities that were able to treat and refer emergencies. Once basic availability was in place, efforts focused first on utilization and then on quality improvement. Key factors were the professionalization of midwifery care (skilled attendants) not in isolation, but as an integral part of an expanding network of facilities that could provide supportive supervision, drugs and equipment, and the back-up of a referral system for treating complications (EmOC) that could not be handled in the rural facilities. In both countries, governments paid serious attention to ensuring access for the poor (progressively closing the gap in utilization of services). Finally, judicious use of information generated through vital registration, death audits and eventually confidential enquiries—including public use of that information to facilitate accountability of public health authorities to the people—encouraged sustained, high-level political commitment to maternal mortality reduction and women’s health.

The experience of Malaysia and Sri Lanka is also instructive because these declines in MMR took place at a time when both countries had very low per capita GNP and, indeed, very modest expenditure on health (comparable to the expenditures and per capita GNPs that are seen today in many very poor, high-mortality countries). The studies conclude that the extraordinary results achieved by

Figure 2 Maternal mortality ratio, Sri Lanka, 1930–1995. Source: Pathmanathan et al. [42].

Figure 3 Maternal mortality ratio, Malaysia, 1950–1999. Source: Pathmanathan et al. [42].
Malaysia and Sri Lanka came not from the level of expenditure, but from pursuing the right policies. Those policies featured the phased development of a widespread, accessible network of facilities able to treat obstetric emergencies and the training and appropriate deployment of professional midwives. The two strategies were seen as complementary, not competing—with emphasis between them shifting over time as MMR declined and the health system developed.

2.4. Ecological studies

A recent ecological study [43] linked population-based estimates of maternal mortality from 16 sites in 8 countries in West Africa with 5 indicators of maternity care, namely, % births with a skilled attendant, % births in any health facility, % births in a health center (any facility that is not a hospital), % births in a hospital (any facility that can perform surgery) and % births by Cesarean delivery. It is likely that many of the hospitals in this study would qualify as basic EmOC facilities, performing all lifesaving skills except blood transfusion, although this was not empirically assessed. Of these five process indicators, three correlated relatively well with estimated maternal mortality: % births with a skilled attendant \((R^2=0.43, p=0.006)\), % births by Cesarean delivery \((R^2=0.34, p=0.027)\) and % births in a hospital \((R^2=0.29, p=0.045)\). There was no association between MMR and % births in a health facility, although in the areas studied most deliveries with a skilled attendant took place in a health facility. While information on emergency obstetric services is incomplete, the study suggests that delivery in a health facility with a skilled attendant is protective, and that EmOC, as measured by % births by Cesarean and % births in a hospital, is also protective.

An important finding of this study is that access to maternity care, and estimated MMRs, are sharply different in urban and in rural areas. Maternal deaths per 100,000 live births (excluding deaths in early pregnancy) were 241 in urban areas and 601 in rural, on average, with wide but not overlapping confidence intervals. In urban areas, most births (83%) took place in health facilities (more likely than not, hospitals), and the majority of these facility births were with skilled attendance. (Some facilities were staffed with people with no midwifery training.) By contrast, in rural areas most (80%) deliveries took place at home with no skilled attendant. While the extent of access to emergency obstetric care for rural women is not known, the overall pattern suggests poorer access for rural women than for urban. For example, for rural women the % births by Cesarean delivery (0.6%) is much lower than the % births by Cesarean for urban women (1.9%). The authors conclude that the higher mortality among rural women is due in large part to their lack of access to maternity services.

Other ecological studies have looked at the relationship between maternal mortality and obstetric and related services. One recent analysis [44] looked at estimated MMRs in developing countries in relation to the adequacy of reproductive health services. The investigators gathered information from experts in 49 developing countries on the state of various maternal health services in 1999–2000. Four broad classes of services (pregnancy avoidance [family planning and abortion services], prevention of obstetric complications [antenatal care and skilled delivery], risk identification [screening to identify cases without necessarily being able to treat them] and treatment of obstetric complications [EmOC]) were rated by expert opinion using the following categories: facility capacity, access to services and care received.

Regression analyses were run with MMR estimates as the dependent variable and the expert ratings of services as the independent variables. Other potential predictors in the model included national income, education, proportion of the population that is urban, the crude birth rate and the proportion of deliveries involving a skilled attendant.

Services were relatively weak in the countries studied. Access to services and national per capita income were the two factors significantly associated with maternal mortality ratios, suggesting that access to services, regardless of the income of the country, is associated with lower maternal mortality. Among services, those involving emergency treatment of obstetric complications (EmOC) and access to safe abortion services had stronger relationships with maternal mortality than antenatal care or general delivery care, including skilled attendance at birth.

Another ecological study finding that may shed light on the relation between maternal mortality and provision of obstetric care is the correlation between the WHO estimates of MMRs in 1990 and the proportion of deliveries in a country conducted by skilled attendants, from Demographic Health Survey data. The correlation between maternal mortality and skilled attendant at delivery (including physicians, nurses and midwives) is initially impressive \((R^2=0.79)\) [45]. However, the overall correlation between MMR and skilled attendants is highly dependent on which countries are included in the analysis. The correlation generally cited
includes both developed and developing countries. If only developing countries are included, the $R^2$ drops to 0.55 (our analysis). Even more telling, if only countries with MMR greater than 200 are included, the $R^2$ drops to 0.19, indicating that there is virtually no relationship between proportion of skilled attendants at delivery and MMR in medium and high-mortality countries—the very countries of interest for a maternal mortality reduction project. (Note that this low correlation persists despite the fact the MMR estimates in some resource-poor countries are derived using a model that includes the proportion of births by a skilled attendant, a situation likely to spuriously inflate the correlation.) These correlations seem to suggest that it is not the skilled provider alone that accounts for the high correlation between MMR and skilled attendant coverage when all countries are included in the analysis. Countries with low MMR, such as all countries in Europe and North America, have both a high proportion of births attended by a skilled provider and a high proportion of obstetric complications treated with high quality emergency obstetric care.

Another challenge presented in analyses explaining the correlation between MMR and proportion of births attended by skilled attendants is that the category “skilled attendant” includes several types of personnel grouped together. To make the situation even more complex, the data are derived by asking women who delivered them. Women may not be able to distinguish between a midwife and, for example, a nurse with no formal midwifery training, or a midwifery assistant, resulting in misclassification in the “skilled attendant” category. It is instructive, therefore, to stratify by type of provider to have a more nuanced interpretation [46]. In this analysis by Graham et al., the MMR is inversely related to the proportion of deliveries conducted by a physician (the higher the proportion of births delivered by a physician, the lower the MMR), but there is little relationship between a higher proportion of deliveries by nurses and midwives and the country’s MMR. Note that any misclassification would more likely be seen in the analysis of all skilled attendants who are not physicians. See Figs. 4 and 5, below. These findings should not be used to discount the value of nurses and midwives. Rather, these results point out problems with using “skilled attendant” as an indicator. In many countries midwives and nurses lack the training or autonomy to handle obstetric emergencies. They are also more likely than physicians to be operating in lower level facilities that lack the equipment and supplies needed to treat emergencies. It should also be noted that all skilled attendants, even highly trained physicians, require the physical infrastructure, equipment, supplies, organization and support of a functioning health system to be effective. Where that infrastructure (including EmOC) exists, as in Malaysia and Sri Lanka, skilled midwives can be integral to a system that efficiently manages both normal and complicated deliveries and dramatically reduces maternal deaths.

An ecological analysis of the relationship between estimated MMRs in select countries and met need for EmOC (the proportion of expected direct obstetric complications that are treated) was conducted based on data from needs assessments [47—55], with the United States [56] added for comparative purposes. Met need is one of six process indicators of emergency obstetric care endorsed by WHO, UNICEF and UNFPA for measuring progress towards the availability, utilization and quality of this care. A high met need indicates that many women with obstetric complications are
receiving the care they require. As the graph below shows, MMR is inversely related to met need, such that the developing country with the lowest MMR, Sri Lanka, has the highest met need, and countries with the highest MMR, Mozambique, Nepal and Bangladesh, have low met need ($R^2=0.64$). The United States, of course, has both the lowest MMR and the highest met need. Published data on met need are only available for these 12 countries, with few countries of medium to low MMR, thus this analysis is very preliminary (Fig. 6).

![Graph: Correlation between maternal mortality ratio (MMR) and met need for EmOC (12 countries). Sources: Refs. [47,48,50–57].
Notes:

- Estimates of met need are national for the following countries:
  - Public and private facilities surveyed: Bangladesh, Benin, Chad, Senegal and the United States (excluding federal facilities)
  - Public facilities only surveyed: Bhutan, El Salvador, Honduras and Morocco
- Estimates of met need are sub-national for the following countries:
  - Public and private facilities surveyed: Nicaragua (9 out of 17 SILAIS)
  - Public facilities only surveyed: Sri Lanka (16 out of 25 districts) and Uganda (19 out of 56 districts)

3. Weighing the evidence supporting the effectiveness of EmOC

In Table 1, the studies discussed in this paper are assessed using the criteria US Preventive Services Task Force system as discussed previously.

The strength of the evidence is high in the nine studies with a design that places them in the second and third tier in the quality of evidence ranking system used here. No studies are of an experimental design that would give them a top ranking because of the measurement challenges associated with maternal mortality, although many of the specific medical interventions that comprise EmOC have been studied through experimental design. The evidence for the effectiveness of the package of EmOC services combines

- a quasi-experimental study relating availability of EmOC services to reduced maternal mortality,
- observational studies of EmOC in association with reduced maternal mortality in developing countries and
- historical evidence of a close correlation between precipitous declines in maternal mortality and introduction of several of the medical interventions comprising EmOC,
- analysis of declining trends in MMR in developing countries in relation to introduction of EmOC as well as deliveries assisted by professional midwives and
- ecological studies of the relationship of maternal mortality ratios to various aspects of reproductive health services in developing countries.

Taken together, these studies provide a firm evidence base for promoting emergency obstetric care as a key strategy in the prevention of maternal mortality. These conclusions are affirmed by a recent ranking of evidence for interventions for reducing maternal mortality, published by the World Bank [58].
Randomized controlled trial design, which is given such predominance in evidence based medicine, has been criticized as being inappropriate in evaluating the efficacy or effectiveness of large-scale and complex public health interventions [59]. In addition, the challenges in

<table>
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<tr>
<th>First author, year</th>
<th>Type of study</th>
<th>County/area</th>
<th>Quality of evidence</th>
<th>Strength of evidence</th>
<th>Conclusion of study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ronsmans, C., 1997</td>
<td>Quasi-experimental</td>
<td>Bangladesh (Matlab)</td>
<td>II-1</td>
<td>A</td>
<td>when emergency obstetric services are close (less than 2 h travel time), maternal mortality was reduced to the same degree as in program area with midwives posted in health centers with transport to EmOC care</td>
</tr>
<tr>
<td>McCord, C., 2001</td>
<td>Cohort study</td>
<td>Maharashtra, India</td>
<td>II-2</td>
<td>A</td>
<td>EmOC effective in preventing maternal deaths in area with high rate of home delivery (85%); 79% of women with obstetric complications self-referred to a hospital, even though almost all deliveries began at home distance to hospital directly related to maternal mortality</td>
</tr>
<tr>
<td>Hoj, L., 2002</td>
<td>Nested case-control</td>
<td>Guinea-Bissau</td>
<td>II-2</td>
<td>B</td>
<td>the MMR for this population remains high (MMR=327) despite almost 90% of women delivering in health facilities and availability of EmOC; quality of care seems to be the problem</td>
</tr>
<tr>
<td>Etard, J.-F., 1999</td>
<td>Prospective cohort study</td>
<td>Bamako, Mali</td>
<td>II-2</td>
<td>C</td>
<td>maternal mortality declined sharply in the United States and western Europe after 1934 when specific treatments for obstetric complications were introduced professionalization of midwifery and increased % of births with a skilled attendant, backed by facilities providing EmOC, associated with declining MMR over the 20th century correlations relatively strong between MMR and 3 indicators of maternity care—% births with skilled attendance, % births in hospital, and % births by C-section; MMRs in urban areas (~80% women deliver in facilities, usually with a skilled attendant) are much lower than in rural areas (80% women deliver at home with no skilled attendant and poor access to EmOC)</td>
</tr>
<tr>
<td>Loudon, I., 1992</td>
<td>Maternal mortality trend analysis</td>
<td></td>
<td>II-3</td>
<td>A</td>
<td>stepwise regression indicates only two important predictors of MMR: per capita GNP and adequacy of access to maternal health services; of services, EmOC and safe abortion had strongest association with reduced MMR correlation observed between MMR and met need for EmOC (% women estimated with direct obstetric complications who receive treatment)</td>
</tr>
<tr>
<td>Pathmanathan, I., 2003</td>
<td>Maternal mortality trend analysis</td>
<td>Malaysia and Sri Lanka</td>
<td>II-3</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Ronsmans, C., 2003</td>
<td>Ecological study</td>
<td>16 sites in 8 West African countries</td>
<td>III</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Bulatao, R.A., 2003</td>
<td>Ecological study</td>
<td>49 developing countries</td>
<td>III</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>AMDD, unpublished, 2004 (see Fig. 6)</td>
<td>Ecological study</td>
<td>12 developing countries and USA</td>
<td>III</td>
<td>C</td>
<td></td>
</tr>
</tbody>
</table>
measurement of MMR itself make it difficult to design an experimental study of maternal mortality reduction. Thus, we found that there are almost no studies using experimental design in the literature on maternal mortality reduction strategies. While the system of ranking studies developed by the US Preventive Services Task Force incorporates most if not all evaluation methodologies, the intense focus of many decision makers on experimental design may be obscuring the recognition and appreciation of what evidence does exist.

As we mentioned in the Introduction, the evidence for the EmOC strategy is sometimes difficult to separate from the evidence for the skilled attendant at delivery strategy, in large part because these two strategies coexist in countries with low and medium levels of MMR [23, 42, 43]. Skilled attendance and EmOC availability and use do not always vary together [60]. There is little evidence for the outcome of one strategy in the absence of another, outside of historical analyses and a few, isolated situations. Analysis of the Ronsmans study in Bangladesh (South Comparison Area) and the McCord study in India suggests that EmOC can be effective in the absence of delivery by a skilled attendant, as long as obstetric complications are recognized and women self-refer for emergency care of good quality [31, 32]. Historical analysis of MMR trends in Western Europe suggests that having skilled attendance at delivery within the context of a supportive environment (respect from professionals and the community, training and supervision, supply) before the availability of emergency obstetric care lowers MMR to an extent, but MMR remains high. Combining skilled attendants at delivery with EmOC in Western Europe and the United States rapidly and dramatically transformed maternal mortality such that it disappeared as a public health concern within a few years.

The health systems in countries with high MMR typically function at a very low level, providing uneven and low quality services that inspire little confidence in the communities they are intended to serve. Given the evidence that deaths from direct obstetric complications can be avoided through access to good quality emergency obstetric care services—both in settings where home delivery is the norm and in settings where institutional delivery is the norm—it is critical that dilapidated health systems in developing countries with high MMRs be given priority attention. This will not happen without commitment from the international community, governments and the affected communities.

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References


