Maternal mortality in Bangladesh: a Countdown to 2015 country case study

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Summary

Background **Bangladesh is one of the only nine Countdown countries that are on track to achieve the primary target of Millennium Development Goal (MDG) 5 by 2015. It is also the only low-income or middle-income country with two large, nationally-representative, high-quality household surveys focused on the measurement of maternal mortality and service use.**

Methods **We use data from the 2001 and 2010 Bangladesh Maternal Mortality Surveys to measure change in the maternal mortality ratio (MMR) and from these and six Bangladesh Demographic and Health Surveys to measure changes in factors potentially related to such change. We estimate the changes in risk of maternal death between the two surveys using Poisson regression.**

Findings **The MMR fell from 322 deaths per 100 000 livebirths (95% CI 253–391) in 1998–2001 to 194 deaths per 100 000 livebirths (149–238) in 2007–10, an annual rate of decrease of 5·6%. This decrease rate is slightly higher than that required (5·5%) to achieve the MDG target between 1990 and 2015. The key contribution to this decrease was a drop in mortality risk mainly due to improved access to and use of health facilities. Additionally, a number of favourable changes occurred during this period: fertility decreased and the proportion of births associated with high risk to the mother fell; income per head increased sharply and the poverty rate fell; and the education levels of women of reproductive age improved substantially. We estimate that 52% of maternal deaths that would have occurred in 2010 in view of 2001 rates were averted because of decreases in fertility and risk of maternal death.**

Interpretation **The decrease in MMR in Bangladesh seems to have been the result of factors both within and outside the health sector. This finding holds important lessons for other countries as the world discusses and decides on the post-MDG goals and strategies. For Bangladesh, this case study provides a strong rationale for the pursuit of a broader developmental agenda alongside increased and accelerated investments in improving access to and quality of public and private health-care facilities providing maternal health in Bangladesh.**

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Introduction

The Countdown to 2015 for maternal, newborn, and child survival in its 2012 cycle reports that only nine of the 75 Countdown countries are on track to achieve the Millennium Development Goal (MDG) 5 target to reduce the maternal mortality ratio (MMR, maternal deaths per 100 000 livebirths) by three-quarters between 1990 and 2015.[1] We reviewed the experience of Bangladesh, one of the nine countries on track, in the improvement of maternal health as part of a series of in-depth country case studies commissioned by Countdown.

Bangladesh has one of the highest population densities in the world, with a population of more than 150 million and a land size of 144 000 km². Situated at the top of the Bay of Bengal, it is largely surrounded by India. Administratively, the country is divided into divisions (seven), districts (64), Thanas and Upazilas (485) or Municipalities and City Corporations (324), and unions (4546).[2]

Recent economic growth in Bangladesh has been robust, averaging 6% annually between 2001 and 2012 despite periods of political turmoil and frequent natural disasters; income per head reached US$848 per year in 2012. Progress has also been rapid in the social sector with increasing educational levels, especially for women.[3] However, Bangladesh remains one of the poorest countries in the world, with nearly a third (32%) of the population living below poverty and 29% underemployed.[4,5] Total health expenditure has remained low, representing only 3% of gross domestic product (GDP), with only a quarter of health spending coming from the public sector.[6]

Several factors influenced Countdown's decision to invite Bangladesh to undertake this in-depth analysis of the country's progress in improvement of maternal health. First, Bangladesh is one of the very few countries that are on track to achieve the MDG 5 target.[7] Second, Bangladesh is unique among low-income and middle-income countries in having valid, nationally-representative household survey-based statistical evidence of progress towards MDG 5. Third, the reduction in maternal mortality has been accompanied by important changes in other indicators of maternal health and socioeconomic development. These factors render Bangladesh an ideal real-world setting for the study of the

driving forces behind large changes in risk of maternal mortality at a population level.

We explored how Bangladesh achieved these reductions in maternal mortality. We focused on change between 1998–2001 and 2007–10, on the basis of the reference periods of the 2001 and 2010 Bangladesh Maternal Mortality Surveys (BMMS).

Methods

Data sources

We used data from two high-quality and highly comparable household surveys, the 2001 and 2010 BMMSs, for the primary analyses in this study. The BMMSs were designed to assess the situation of the country with respect to maternal health, and particularly to provide national estimates of MMR. Both surveys were large, covering about 100 000 households in 2001 and 174 000 households in 2010, and nationally representative, using a three-stage sampling design.[8,9] Deaths of women of reproductive age (aged 13–49 years) were followed up for verbal autopsy during roughly 4 years before the surveys with an adapted version of the WHO structured questionnaire.[10] Two independent physicians reviewed data from verbal autopsies to assign cause of death, including maternal causes (with a third physician reviewing the data if they disagreed on the cause of death). Both surveys also obtained information about selected background characteristics, a full birth history from ever-married women aged 13–49 years to provide denominators for calculating the MMR, and about several indicators of maternal health, such as the frequency of problems encountered during the index pregnancy and childbirth, health-seeking behaviours, and intervention coverage (appendix).

We also obtained data for coverage of maternal health and other interventions and for contextual factors from published data from the six Bangladesh demographic and health surveys done between 1993 and 2011.[11] We obtained information about policies and programmes in maternal and reproductive health through a rigorous desk review, which primarily drew on policy documents and technical reports from the government, non-governmental organisations (NGOs), and development partners working in the health sector in Bangladesh.

Statistical analysis

The analysis focused on a comparison of the 3-year periods preceding the 2001 and 2010 surveys. Overall estimates of maternal mortality were obtained as follows. We calculated maternal mortality rates for each period by dividing the number of maternal deaths in a particular age category by the exposure time (women-years) in that age category. We then calculated the MMRs by dividing each age-specific maternal mortality rate by the corresponding age-specific fertility rate. We computed standard errors using the Jackknife repeated replications procedure.[12] We decided to focus on obstetric risk, or risk per birth, as measured by MMR, rather than risk per woman-year of exposure, as measured by the maternal mortality rate; a dominant influence on the maternal mortality rate is the level of fertility, whereas our interest was in risk per risky event. Accordingly, we created a pooled dataset of births (for women who survived) or pregnancies (for women who died from maternal causes) in the 3 years before each survey, with characteristics of the mother whether she survived or died, using the two BMMS rounds. The variables included in the pooled dataset were whether the mother died, if so whether the cause of death was maternal, socioeconomic and demographic characteristics, and maternal care-seeking behaviours. Our pooled data set excluded previous livebirths in the 3-year windows to women who subsequently died, but any bias from this exclusion was likely to be small.

See Online for appendix

We did a Poisson regression analysis on the combined data file at the individual pregnancy or birth level to explore relations between the change in risk of a maternal

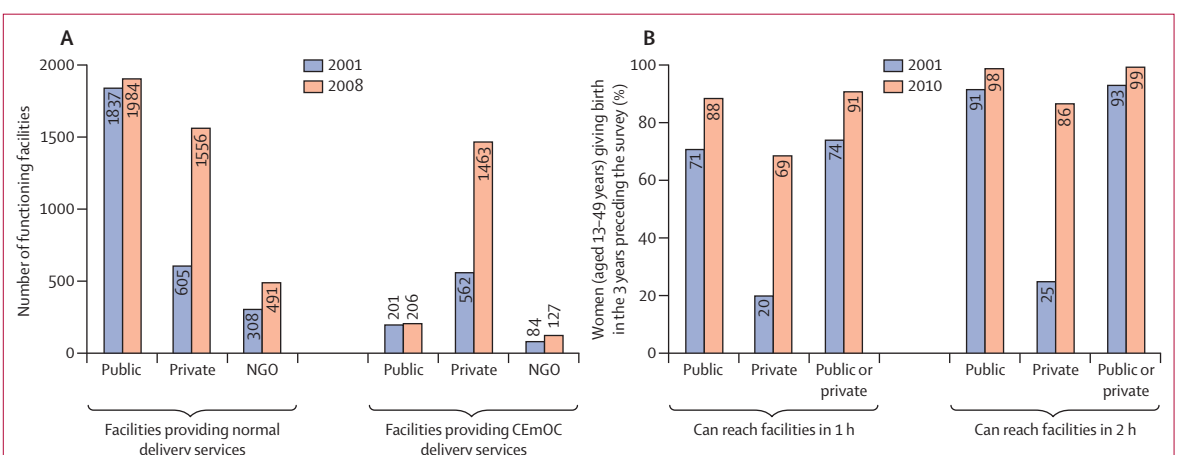

Figure 1: **Access to health facilities, 2001 and 2010**

(A) Number of functioning facilities providing delivery services.[18] (B) Number of individuals able to reach facilities. NGO=non-governmental organisation.

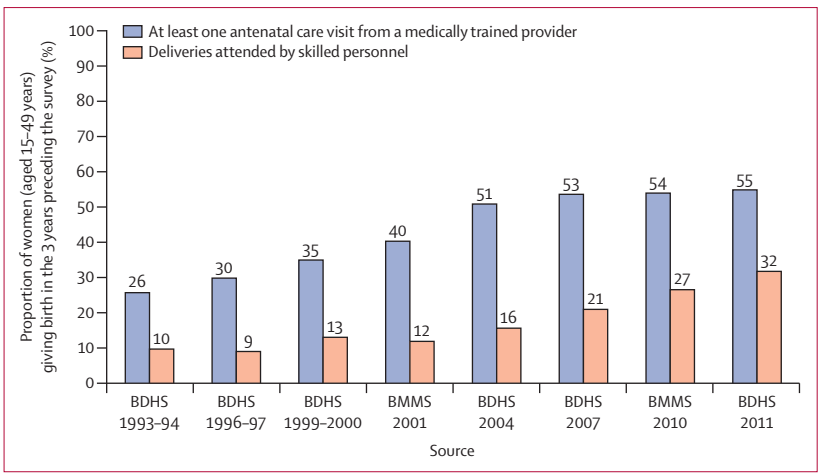

Figure 2: **Trends in national coverage of antenatal care and skilled birth attendance**
BDHS=Bangladesh demographic and health survey. BMMS=Bangladesh Maternal Mortality Survey.

death from 2001 to 2010 and a range of demographic, socioeconomic, and health-care factors. Because of concerns about reverse causation between service utilisation and obstetric problems, we computed indicators of service use as Thana-level averages for surviving women. We also applied a non-linear decomposition method on the pooled dataset to decompose changes over time. Lastly, we calculated the total number of maternal deaths averted between 2001 and 2010 and estimated attributable fractions (appendix). We did all statistical analyses using the Stata statistical software, version 12.1.[13,14]

Role of the funding source

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the paper. The Countdown to 2015 for Maternal, Newborn and Child Survival reviewed and provided feedback on the manuscript and approved it as an official Countdown to 2015 case study.

Results

MMR in Bangladesh substantially decreased from 322 (95% CI 253–391) deaths per 100 000 livebirths in 1998–2001, to 194 (149–238) deaths per 100 000 livebirths in 2007–10. The implied average annual rate of decrease is 5·6%, slightly faster than the average annual reduction rate required (5·5%, based on the formula: $P_t = P_0 \times e^{rt}$; for which P_t is the value at time t, P_0 is the initial value, r is the growth rate, and t is the time in years) between 1990 and 2015 to meet the MDG 5 target. The reduction in MMR was similar in urban (41% decrease) and rural (39% decrease) Bangladesh (appendix). The MMR estimates from the two BMMSs were consistent with the long-term trends noted in other data (appendix). Even though direct obstetric causes of death also substantially decreased between 2001 and 2010 (eclampsia by 50%, haemorrhage by 35%, obstructed labour by 26%, and abortion by 85%), most of these causes of deaths were still important in 2010 (appendix).

What explains this 40% reduction in maternal mortality in Bangladesh in less than 10 years? We first examined major policy formulation and programme initiatives relevant to maternal health (appendix). A series of 5-year plans focused on development of comprehensive maternal and child health services and access to family planning services.[15] During the late 1980s, the government focused on providing core services for maternal and child health for the rural population through district hospitals, Upazila (previously Thana) health complexes, union family welfare centres, and 73 500 field workers and 30 000 satellite clinics. The primary focus was to promote antenatal care, tetanus toxoid immunisation, iron supplementation, clean delivery practices, and family planning. In the 1990s, an Emergency Obstetric Care (EmOC) programme was initiated, upgrading existing government facilities as comprehensive EmOC (CEmOC) facilities.

A sector-wide approach was introduced in 1998, marking a shift towards more integrated, better-planned delivery of health services. Home-based services were shifted to services from community clinics, each covering 6000 people in rural areas, and expanding provision of EmOC services from health facilities.[16] The 2001 National Strategy for Maternal Health has guided subsequent health sector-wide approaches since 2003, resulting in major investments in the following areas: establishment and upgrade of health facilities to deliver CEmOC services and train community-based skilled birth attendants to promote safe delivery at home; stimulation of demand for maternal health services through demand-side financing; and strengthening of health education and communication activities towards behaviour change in reproductive health.[17]

Second, we examined availability of, and access to, reproductive and maternal health services. Both availability and access to facilities offering delivery services improved substantially during the past decade. The number of public sector facilities offering either normal delivery or CEmOC services showed almost no increase from 2001 to 2008 (the latest year available), and while the number of NGO facilities increased substantially, their share remained small. Private facilities more than doubled, and by 2008 they constituted 39% of all facilities offering normal delivery services (up from 22% in 2001) and 81% of all CEmOC facilities (up from 66% in 2001; figure 1A).[18] Higher proportions of respondents in the 2010 survey reported that they were able to reach a facility within either 1 h or 2 h than did those in 2001 (figure 1B); consistent with the data for changes in numbers of facilities, the improvement was particularly sharp for private sector facilities, from 20% in 2001 to 69% in 2010 within 1 h and from 25% to 86% within 2 h. Even though there was no real increase in public sector facilities, the reported improvement in access to public sector facilities might have been largely due to improved transportation.

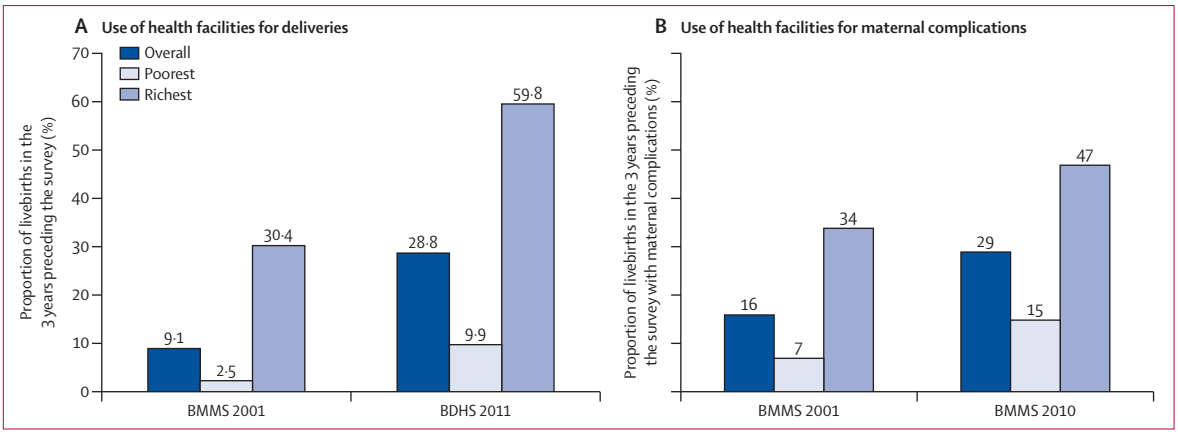

Figure 3: **Inequity in use of health facilities, by wealth quintiles**
(A) Use of health facilities for deliveries. (B) Use of health facilities for maternal complications. BDHS=Bangladesh demographic and health survey. BMMS=Bangladesh Maternal Mortality Survey.

Third, we assessed changes in coverage of key reproductive health interventions during this period. Use of maternal health services also increased during this period. Figure 2 shows that coverage of antenatal care doubled during 1993–2011—although it sems to be plateauing at about 55%—and there was more than a three-fold increase in deliveries by medically trained providers, with almost all of this increase occurring after 2001. 64% of the increase in deliveries by medically trained providers was contributed by private facilities (appendix). Skilled attendance at home deliveries did not change and remained at about 3%. During the same period, the overall caesarean section rate increased seven-fold (2·6–17·1%) and now exceeds the WHO-recommended level of 15%.[8,19]

The disparity between the richest and poorest quintiles in the use of health facilities for deliveries remained during this period, even though there was a substantial increase among the poorest women (up to 10%; figure 3). Respondents also reported increased care-seeking for maternal complications, with the use of facilities almost doubling to 29% in 2010. The use of health facilities for maternal complications doubled even among the poorest, although the inequity was sustained between the richest and poorest quintiles. A similar pattern was noted between women with secondary or higher education and those with no education (appendix).

Between 2001 and 2010, fertility dropped by 0·7 child per woman (from 3·2 to 2·5 children per woman), consistent with the steady increase in the use of modern contraceptives (figure 4). The reduction in fertility was mainly among older, higher-parity women, thus contributing to MMR decrease.

Fourth, we examine changes in contextual factors relevant to maternal health. Since 1993–94, the country has witnessed major improvements in female education—the proportion of ever-married women aged 15–49 years with secondary or higher education increased

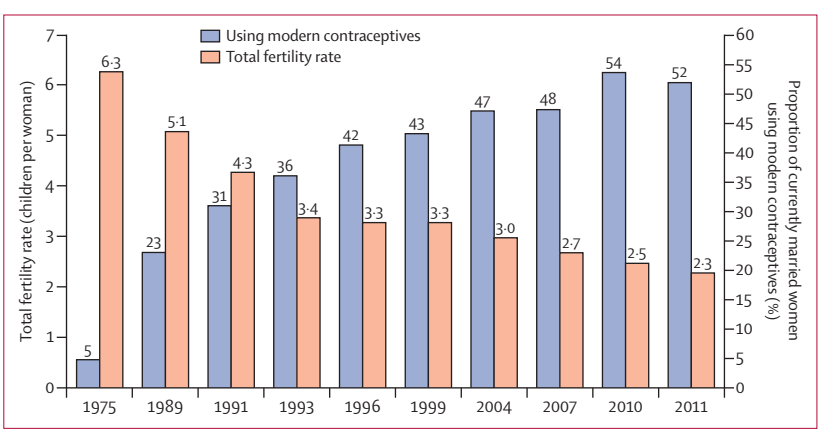

Figure 4: **Trends in use of modern contraceptives and total fertility**

	2001		2010	
	n	Mean (SD)	n	Mean (SD)
Mother variables				
Maternal death	54 250	0·0034 (0·0584)	61 285	0·0021 (0·0458)
First pregnancy	54 250	0·2876 (0·4526)	61 285	0·3395 (0·4735)
Birth parity ≥4	54 250	0·3012 (0·4588)	61 285	0·2001 (0·4001)
Birth at age <20 years	54 250	0·2173 (0·4124)	61 285	0·1572 (0·3640)
Birth at age ≥35 years	54 250	0·1087 (0·3113)	61 285	0·0872 (0·2822)
Years of education	54 250	3·108 (3·639)	61 285	4·993 (3·780)
Household variables				
Economic status (0-low to 6-high)	54 250	1·815 (1·426)	61 285	2·593 (1·442)
Urban residence	54 250	0·1728 (0·3781)	61 285	0·2344 (0·4236)
Thana-level averages				
Caesarean sections	53 322	0·0262 (0·0410)	60 383	0·1230 (0·1045)
≥4 antenatal visits	53 322	0·1117 (0·1121)	60 383	0·2220 (0·1497)
Skilled delivery help	53 322	0·1158 (0·1090)	60 383	0·2661 (0·1650)

n is the (unweighted) number of births; means and standard deviations reflect weighted values.

Table 1: **Descriptive statistics by variable for 2001 and 2010 surveys**

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Survey round	0·629 (0·503–0·786)	0·716 (0·570–0·898)	0·702 (0·557–0·885)	0·709 (0·558–0·901)	0·768 (0·586–1·006)	0·841 (0·648–1·090)
First pregnancy	..	0·571 (0·394–0·830)	..	..	..	0·640 (0·460–0·891)
Fourth or higher pregnancy	..	1·806 (1·372–2·378)	..	..	..	1·678 (1·276–2·207)
Pregnancy at age <20 years	..	1·258 (0·841–1·884)	..	..	..	..
Pregnancy at age ≥35 years	..	1·789 (1·330–2·407))	..	..	..	1·810 (1·345–2·436)
Mother's years of education	..	..	0·944 (0·915–0·975)	..	..	..
Economic status*	..	..	..	0·891 (0·819–0·969)	..	0·939 (0·862–1·023)
Urban residence	..	..	..	0·917 (0·689–1·220)	..	..
Thana-average delivery by caesarean section	..	..	..	..	1·234 (0·070–21·621))	..
Thana-average ≥4 antenatal visits	..	..	..	..	1·391 (0·420–4·607)	..
Thana-average delivery by skilled birth attendant	..	..	..	..	0·165 (0·029–0·927)	0·4004 (0·152–1·075)
Constant	0·0034 (0·0030–0·0040)	0·0026 (0·0021–0·0033)	0·0040 (0·0034–0·0048)	0·0042 (0·0035–0·0051)	0·0040 (0·0033–0·0049)	0·0034 (0·0026–0·0044)

Data are risk ratios (95% CI). *Combination of ownership of TV, motorcycle, wardrobe, and housing with roof of tin, tile or cement, walls of brick, cement or tin, and floor of cement, tiles or polished wood.

Table 2: **Associations of risk of maternal death and independent factors**

from 15% to 42% (appendix). The Female Secondary School Stipend Scheme, which provided government support for about 3·4 million young girls from poor families annually, contributed to increased enrolment among girls.[20] More women are now exposed to mass media, which might have contributed to increased awareness about maternal health and improved health-seeking behaviours (appendix). Increasing proportions of women live in urban areas contributing to better access to health care. Bangladesh witnessed a phenomenal growth in ownership of mobile phones during this period, going from 0·2 mobile subscriptions per 100 inhabitants in 2000 to 46 subscriptions per 100 in 2010—an expansion of 230 times in a decade, and equivalent to 66·6 million active subscriptions.[21]

The economic conditions of households have also substantially improved in this period. National income per head almost doubled, with a corresponding reduction of 36% in the percentage of the population living below the national poverty line.[3] Meanwhile, the percentage of undernourished women (ie, with body-mass index [BMI] lower than 18·5) nearly halved (from 52% in 1996–97 to 28% in 2011).[19]

We did a statistical analysis to explore the relative contributions of these various factors to maternal mortality decline. Table 1 summarises the proportions of births in the preceding 3 years by variables of interest available from the 2001 and 2010 surveys. All the variables show a shift towards a lower risk profile: for example, the proportion of births of parity 4 and higher declined from 30% to 20%, and the average number of years of education of the mothers increased by nearly 2 years.

Table 2 shows the associations between risk of maternal death and various categories of risk factors controlling for background characteristics. Results are shown for six models of the type shown in equation (1) applied to the pooled dataset (appendix). The outcome variable is the natural log of the risk of dying of maternal causes associated with a pregnancy or birth. In the first model, controlling only for survey round, the risk of having a maternal death decreased by 37% (95% CI 21–50) from 2001 to 2010, very similar to the actual MMR decline of 40%. Model 2 controls for changes in four aspects of fertility dynamics. Three of the four variables are highly significant—high parity births and births after age 35 years increase risk substantially; surprisingly a first pregnancy is found to be substantially protective. Model 3 shows mother's (completed) years of education to be associated with a reduction of maternal risk of about 5% (2–8) for every year of education. Model 4 controls for household-level variables—the economic status variable is associated with an 11% (3–18) reduction of risk per item, whereas urban residence makes no significant contribution. Model 5 controls only for utilisation at the Upazila level of maternal health services—both the proportion of deliveries by caesarean section and the proportion of pregnancies with four or more antenatal care visits are associated with increased risk, albeit non-significantly; the caesarean section result is perhaps not surprising since use has increased beyond any likely level of need. The proportion of deliveries assisted by a skilled attendant, however, is both strongly protective and significant (p=0·05), with a 1% increase in average skilled attendant use being associated with a 0·8% (0·1–1·0) reduction in risk. Once the service utilisation variables are included in the model, the change in risk from 2001 to 2010 (coefficient on survey round) ceases to be significant.

The model 6 in table 2 includes all the variables that achieved a significance level of 0·15 or better when all the variables were included. The model thus includes both a background variable (economic condition) and more

proximate factors (fertility, health service use). First pregnancies remain protective, and both high parity births and births at age 35 years or over remain highly significant risk factors. The one distal factor, household economic status, remains protective but loses significance—further analysis (data not shown) indicates that the risk-reducing effect of maternal education in model 3 worked through reductions in high-risk births. Use of a skilled attendant at birth remains protective and is marginally significant (p=0·069); if interpreted as an indicator of the effect on individual risk, having a skilled attendant at delivery reduces risk by as much as 60%. The largest reductions are through increased use of skilled birth attendant (22%) and the reduction in high parity births (12%); although highly significant, the overall effect of reductions in births to women older than 35 years was small (3%). Once again, in this model the change in risk from 2001 to 2010 not accounted for by specific variables loses significance.

Decomposition analysis was done (results not shown) on the final model to explore whether change in maternal mortality resulted from structural changes in the study population (eg, a higher proportion of educated mothers in 2010 than in 2001) or changes between surveys in the effect of the predictors (eg, the stronger effect of education in 2010 than in 2001) over the survey rounds. Differences in proportions of first pregnancies, high-parity births, and births to women older than 35 years all contributed significantly to reduced risk (p=0·007 for first pregnancies, p=0·011 for high-parity births, and p=0·002 for births to women aged >35 years), whereas changes in economic status and in skilled birth attendance were associated with reduced risk, but not significantly so. Effects of changes in effect sizes between the two surveys did not even approach significance.

The statistical analysis indicates that the increase in use of skilled attendants at birth, almost all of which was deliveries in facilities, and the shifts in fertility patterns contributed to the decrease in maternal mortality risk between 2001 and 2010, confirming the roles of improved access and reduced fertility described earlier. However, about two-thirds of the decrease in risk cannot be explained by the factors for which we have measures, partly because of measurement error in the variables we do observe.

On the basis of the 2001 female age distribution, age-specific fertility rates and MMR, we estimated that the number of maternal deaths in Bangladesh in 2001 was 12 114. This number would have increased to 14 310 in 2010 if birth rates by age and parity, and maternal death rates within every age and parity category had remained unchanged from 2001. Instead, the actual estimated number of maternal deaths in 2010 was 6848 (ie, 52% of the deaths had been averted). 21% of the deaths had been averted because of the reduced number of births and another 7% because of changes in maternal age and parity distributions; 24% of the maternal deaths had been averted because of reduction in risks of maternal deaths within age and parity categories, largely we argue a consequence of the increased care-seeking reported here.

Discussion

At the current rate of MMR reduction, Bangladesh would reach the MDG 5 target of 143 per 100 000 livebirths by 2014, a year ahead of schedule. This rate of reduction is very similar to that noted in the ICDDR,B Matlab Government Service Area (5·3%; appendix). In their 2010 modelled estimates of maternal mortality in 181 countries,[22] Hogan and colleagues had reported an annual rate of decrease of 6·4% for Bangladesh for the period 2000–08.[22] The 2012 WHO/UNFPA/UNICEF/WB model estimates arrive at an annual rate of decline of 5·9% from 1990 to 2010.[7] There is thus clear consensus that the MMR has decreased very rapidly in Bangladesh.

The data presented in this paper provide clear evidence that the decrease was the result of factors both within and outside the health sector. Our statistical model shows important effects of changes in the age and parity distribution of births between 2001 and 2010, increases in the use of a skilled attendant at delivery, and improved economic status of households. The key question is what explains this exceptional reduction in maternal mortality?

The fertility reduction between 2001 and 2010 contributed to averting maternal deaths through two mechanisms: the larger effect (21% of deaths averted) is due to the sheer reduction in number of births, and an additional 7% of the deaths were averted due to the change in the age pattern of mothers (towards ages 20–34 years) and shifts in parity (fewer high parity births). A 2011 publication had estimated a similar overall contribution of fertility reduction,[23] although our estimate of the contribution of the reduction in number of births is much higher. There is substantial scope for further reducing fertility and averting maternal deaths as the reported desired fertility rate is only 1·6 children.[19]

Between 2001 and 2010, care-seeking for delivery care from health facilities more than doubled, and improved across all socioeconomic groups. However, use of skilled birth attendants, which was almost entirely in health facilities, reached 32% overall, and was only 12% among the poorest socioeconomic quintile in 2011.[19]

We believe that several factors have contributed to the increased use of health facilities and maternal health care-seeking, evident from the doubling in the proportion of deliveries by skilled personnel as well as the use of facilities for maternal complications seen in this study, and the estimated 59% increase in treatment-seeking for abortion complications reported in a recent publication.[24] First, there has been a substantial increase in the availability of, and access to, health facilities, particularly private sector facilities after 2001; policy changes had created an enabling environment for the expansion of maternal health-care services. Although most of the expansion of EmOC facilities happened before 1998,

Panel: **Research in context**

Systematic review

Bangladesh had a 40% decrease in maternal mortality over the past decade. We searched in PubMed using the search string ((“maternal mortality”) OR (“maternal death”)) AND (“Bangladesh”), for papers published since Jan 1, 2000. Among the 123 papers found, only four[23,29-31] attempted to describe the determinants of maternal mortality decrease over time in Bangladesh, which was our primary research question. Three of the studies were based on the same small area and population of Matlab, a subdistrict in Bangladesh and covering overlapping time periods,[29-31] and the fourth involved secondary analysis of national data from three south Asian countries including Bangladesh to estimate relative contributions of fertility decreases and maternal care to the reduction in maternal mortality.[23]

Interpretation

Bangladesh is unique among low-income or middle-income countries in having two large, nationally representative, high-quality household surveys focused on maternal mortality. We statistically assessed the changes in risk of maternal death between 2001 and 2010 in terms of demographic, socioeconomic, and health-care factors using national-level data. This is, to our knowledge, the first systematic presentation of evidence for a low-income or middle-income country explaining impact of health and non-health factors on maternal mortality at national scale. Our findings not only confirm the role of various factors previously presented as possible explanations for decreases in maternal mortality,[29-31] but also quantify their contributions. The analysis provides rigorous evidence that the impressive decrease in MMR during the past decade in Bangladesh is attributable to factors both within and outside the health sector. For Bangladesh, this case study provides a strong rationale for the pursuit of a broader developmental agenda alongside a strategic focus on improving the effectiveness of public and private health sector facilities. These findings also hold important lessons for other countries as the world discusses and decides on the post-MDG goals and strategies.

health sector-wide approaches ensured the better availability of human resources, drugs, and equipment to make the EmOC facilities more functional.[17,25,26]

Second, the transportation sector has substantially improved, increasing access to health facilities. Between 2001 and 2010, 19 000 km of dirt roads and 32 000 km of paved roads were constructed.[5] Because travel times are increased by the need to cross the hundreds of rivers in the country, the addition of almost 300 km of bridges also increased access to health facilities. Bangladesh is the most densely populated of countries with over 10 million people, with more than 1000 people per km² (appendix). This density in population implies that distance (eg, to health facilities) is likely to be much less of a barrier in Bangladesh than in other countries with large populations.

Third, the communications sector has rapidly grown, with increases in television viewing and ownership of mobile phones. Around two out of three households across the country now have a mobile phone, and thus access to information, assistance, and a wider and more responsive social network; a qualitative study[27] of BMMS 2010 indicated that access to mobile phones indeed facilitated getting treatment.

We also take note of two other factors, education and socioeconomic status, that have contributed to the improvement in maternal health through both increased use of health facilities and other pathways. Because of the change in fertility, most births in Bangladesh now take place among women in their early 20s, the same age range in which recent increases in schooling have been largest. Between 2001 and 2010, the proportion with at least some secondary schooling almost doubled from 26% to 44%.[19] This change surely has implications for negotiating power within the family, for birth planning, for levels of awareness of maternal complications, for the potential to respond effectively to maternal complications, and for the ability to navigate the health-care system.

Improvements in household economic conditions also contributed to increases in maternal survival (model 4, table 2). Health facility utilisation is much greater among the richer households, who are definitely more able and willing to pay for services from the increasingly widespread private health facilities. Also, one of the outcomes of better economic status is portrayed in the improvement in nutritional status in women, with a consequent reduced risk of maternal morbidity and mortality.[28,29] Our findings from this national study confirm and quantify the contributions of various factors previously presented as possible explanations based on analysis of maternal mortality data from a demographic surveillance system in a rural subdistrict of Bangladesh.[30–32]

Nevertheless, maternal care-seeking rates are still quite low in Bangladesh, and it is challenging to relate them to the large decrease in maternal mortality. Absolute maternal indications are a specific set of life-threatening complications that require a major obstetric intervention (eg, caesarean sections) to avoid a maternal death.[33] In 2005, an assessment in 12 Bangladesh districts showed that 27–76% of deliveries with absolute maternal indications had received a major obstetric intervention.[34] The near doubling of use of health facilities for maternal complications and deliveries from 2001 to 2010 would have resulted in a further increase in the met need for essential obstetric care and in a contribution to the decline in maternal mortality larger than might be suggested by the absolute level of care-seeking. Many of the caesarean sections done in the health facilities (now 17% of all deliveries) are very likely to be clinically unnecessary.[35] However, an increasing proportion of the true need (ie, absolute maternal indications, previously estimated at only 0·7% of deliveries in Bangladesh[34]) is possibly being met by these increasing caesarean section rates. The fact that only the direct obstetric causes of deaths decreased during 2001–10 (by 45%) and not the indirect obstetric causes (which would be less likely to be affected by currently available services) lends support to our argument.

Our analysis is limited by the data that were available in the 2001 and 2010 BMMSs, which did not collect information on nutritional status, objective data on access to health facilities by type of EmOC services available, or on maternal complications to enable valid judgments on whether a particular health service was needed. To cover the latter, we opted in our statistical analyses to use

Thana-level means of service utilisation as the variables of interest; the use of such approximations introduces measurement errors, however, that could account for the failure to explain more than a third of the MMR reduction.

In summary, Bangladesh has achieved remarkable reductions in maternal mortality by investing heavily in female education and achieving reductions in fertility, and more specifically by increasing the availability of CEmOC facilities. This case study examined both health and non-health determinants of maternal mortality with the intent to not only understand and guide the Bangladesh programme, but also to influence regional and global discourse on approaches to ensuring ever greater reductions in maternal mortality. The evidence presented here provides a strong rationale for accelerating access to and the quality of health-care facilities providing care for maternal complications and safe delivery services in Bangladesh.

Contributors

KJ, PKS, KH, and SEA conceptualised the analysis, which were done by them and QN and KZA. SEA and KZA prepared the data and analysis of contextual factors with assistance from KH. All authors, except KJ, participated in a weeklong workshop in Dhaka, Bangladesh, in March 2013, to review and interpret the preliminary results. KZA, SEA, QN, PKS, and KH produced the first draft of the paper. All authors reviewed and contributed to subsequent drafts and approved the final version for publication. The corresponding author had full access to all of the data used in the study and had final responsibility for the decision to submit for publication.

Declaration of interests

We declare no competing interests.

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