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DEMOGRAPHIC, PROGRAMMATIC, AND SOCIOECONOMIC CORRELATES OF MATERNAL MORTALITY IN MATLAB, BANGLADESH

Mizanur Rahman
Pathfinder International
MizanurRahman@pathfind.org

Julie DaVanzo
RAND

Abdur Razzaque
ICDDR,B: Centre for Health and Population Research

Kapil Ahmed
Pathfinder International

Lauren Hale
State University of New York, Stony Brook

Introduction

Although declining, maternal mortality in Bangladesh is high by any standards. A better understanding of the factors associated with maternal mortality will help health and family planning programs to develop strategies to make pregnancy and childbirth safer for women. Because of unavailability of adequate data, little is known about the demographic, socioeconomic, and programmatic factors that may affect maternal mortality in developing countries. In this paper, we use high-quality, prospective data from the Matlab Demographic Surveillance System (DSS) on nearly 143,000 pregnancy outcomes to examine correlates of maternal mortality during the period 1982-2002.

We attempt to answer four questions:

1. How is likelihood of maternal mortality associated with the outcome of the pregnancy (live birth, stillbirth, miscarriage, or induced abortion)?
2. How is maternal mortality associated with reproductive patterns -- maternal age, gravidity, the duration of the preceding interpregnancy interval, and previous pregnancy loss and child death?
3. Do levels and trends in maternal mortality differ between the Treatment (MCH-FP) and Comparison Areas of Matlab?
4. How does maternal mortality vary with socioeconomic factors?

Background

Pregnancy outcome

A woman is exposed to the risk of a "maternal death" from the day of conception until 42 days after pregnancy outcome. The woman may die from complications while she is pregnant before an outcome or during or after (in 42 days) the delivery of a live birth or stillbirth or during or after an induced abortion or miscarriage, stillbirth. Induced abortion by unsafe means is an important cause of maternal mortality in many developing countries (REF). However, safe abortions provided by trained providers, available in selected developing countries, generally do not elevate women's risk of mortality (REF). In Bangladesh, both safe abortion (known as menstrual regulation) and unsafe abortions are practiced, and the former has been gradually replacing the latter (DaVanzo et al., 2003). Miscarriage and stillbirth, incidences of which are associated with general health of the women and related factors, also carry risks for maternal mortality. In Bangladesh, over 15 percent of pregnancies end up in non-live births (REF). We compare the mortality risks of having a non-live birth with those having a live birth.

Demographic factors and maternal mortality

The presumed relationship between demographic factors and maternal mortality can best be captured by a commonly cited assertion found in demographic and reproductive health literature in the context of developing countries that four "too's" are associated with higher risks of maternal mortality: It is believed that *too young* motherhood, *too short* an interval between births, having *too many* births, and *too old* motherhood are each pernicious for mothers' health in general and are associated with a greater likelihood of maternal mortality in particular (REF). However, there has been relatively little research on the effects of these "too's" on maternal mortality and of other reproductive patterns (e.g., very long interpregnancy intervals, histories of previous pregnancy losses or child deaths) or of socioeconomic and programmatic factors. We examine such relationships in this study.

Maternal age

A girl continues to grow physiologically and mentally until age 20 and beyond. It is widely believed that her physiology is not yet fully ready to bear a child before this age; or putting it differently, when a girl gets pregnant there is competition between her growth and that of her fetus (REF). Therefore, a pregnancy before age 20 may lead to relatively greater physiological stresses and, because of this, to higher morbidity and mortality. In developing countries where childbearing often takes place at early age, it is often found, in the bivariate relationship, that both maternal mortality and infant and child mortality are high among mothers under age 20 than others (REF). Such an observed relationship, however, is confounded by the fact that pregnancies at a young age are likely to be first pregnancies, and first pregnancies have higher risks for maternal mortality (REF). Furthermore, research on the United States that controls the effects of socioeconomic, behavioral, familial, and environmental factors shows that teenagers do not experience greater risks of maternal mortality than older women. It is argued that it is not the young mother's biology but the other (e.g., socioeconomic) factors that lead to higher risks of childbearing (REF). In a companion study in Matlab, we found that teenagers actually have significantly *lower* risks of having pre-eclampsia and proteinuria (Razzaque et al. 2004).

Pregnancy spacing

It has been asserted that births that are "too" closely spaced carry a risk both for the child's and mother's health mainly through hypothesized maternal depletion syndrome in which it is believed that it takes a reasonable amount of time for a woman to recover from the physiological stresses associated with the previous pregnancy (e.g., Khan et al., 1998; Miller, 1991; Winikoff, 1983; and Winkvist et al., 1992). Repeated pregnancies in a short period can lead to certain morbidities and nutritional deficiencies that are risk factors for own survival and for their children's health.

Closely spaced births have been found to be associated with poorer child health and survival in many different countries (e.g., Cleland et al., 1984; Rutstein, 2003; DaVanzo et al., 2004). There have been relatively few studies of whether there is such an effect on *maternal* health (morbidity and mortality). Some studies have documented through a bivariate analysis that short intervals are risk factors for maternal mortality (e.g., Anandalakshmy et al., 1993; Miller et al., 1992; and Winikoff, 1983). In a case-control study in Matlab, Bangladesh, Ronsmans and Campbell (1998) conducted found no evidence of a relationship between maternal mortality and the duration of the preceding interpregnancy interval after controlling the effects of some confounding variables.

However, Conde-Agudelo and Belizán (2000), in a study of pregnancies in Latin America, showed that maternal mortality was 2.5 times higher among women who had an interpregnancy interval of less than six months than among women having an interpregnancy interval of 18-23 months, after controlling for the effects of maternal age, gravidity, body mass index before pregnancy, history of miscarriage, marital status, education, and smoking habits. Mortality was not significantly higher for other interval groups. Conde-Agudelo and Belizán also find that eclampsia, third-trimester bleeding, premature rupture of membranes, puerperal endometritis, and anemia were significantly higher among women who had an interpregnancy interval of less than six months than for women who had an interval of 18-23 months. Pre-eclampsia, postpartum hemorrhage, and gestational diabetes mellitus were not associated with short interpregnancy intervals. However, Conde-Agudelo and Belizán found that pre-eclampsia, eclampsia, and third-trimester bleeding were higher among women who had an interpregnancy interval of 60 months or longer. In a companion study we showed that pre-eclampsia and high blood pressure are more likely in Matlab for women with preceding interpregnancy intervals of less than six months and 75 months or more compared to those with intervals of 27-50 months (Razzaque et al. 2004). Edema was also more prevalent among women with intervals of 50 months or more.

Number of pregnancies (gravidity)

It is also believed that maternal mortality increases with the number pregnancies (also known as gravidity). This relationship may be confounded by pregnancy interval and maternal age. This is because, for a given age at first pregnancy, the number of pregnancies by some subsequent age will be greater if those pregnancies are more closely spaced and also because when number of pregnancies increases, maternal age also increases.

Maternal survival improvement in Bangladesh: Trends in maternal mortality in the MCH-FP and Comparison Areas of Matlab

The maternal mortality ratio is high in Bangladesh, although it has declined from over 5 maternal deaths per 1,000 live births during the 1980s to around 3 deaths per 1,000 live births in the late 1990s through 2001 (NIPORT 2002). In two rural areas it was around 6 per 1,000 live births during 1982-83 (Alauddin 1986; Khan et al., 1986). In Matlab, the maternal mortality ratio was between 5 and 7 per 1,000 live births during the late 1960s and early 1970s (Chen et al., 1974) and around 5 during the late 1970s to mid-1980s (Koenig et al., 1988). It declined to about 3 deaths per 1,000 live births by the early 1990s (Maine et al., 1996; Ronsmans et al., 1997). These ratios are roughly 8-10 times higher than that was found in 19 countries in Latin America and the Caribbean during the late 1990s (Conde-Agudelo and Belizán, 2000). In India and Sri Lanka during 1990s, the maternal mortality ratio was 5 and 0.9 per 1,000 live births, respectively (www.unicef.org/infobycountry).

It is expected that maternal mortality rates (maternal deaths per 1,000 women) will decline with fertility decline for several reasons. With fewer pregnancies, women have less exposure to the risk of maternal mortality. Analyzing data on the late 1970s and the first half of the 1980s, Koenig and his colleagues (1988) found a significantly lower maternal mortality *rate* in the area of Matlab (the Treatment Area) that has better family planning services and lower fertility rates (than the Comparison Area). They found, however, that the maternal mortality *ratio*, where the denominator is live births, was similar in the two areas. Hence, the lower maternal mortality rate during this period in the Treatment Area was a result of the lower birth rate. The maternal mortality ratio more closely measures the risks associated with pregnancies, that is, how likely it is for a woman to experience maternal death once she is pregnant.[1] This depends on the availability of health services for pregnant women, including delivery facilities that can effectively tackle complications and other live-saving procedures. During the period considered by Koenig et al. (1988) the Treatment Area did not have different services for deliveries than the Comparison Area.

In subsequent years, maternal mortality ratio declined equally in both areas of Matlab. Maine and her colleagues (1996) and Ronsmans and her colleagues (1997) found that the principal reason for these declines was associated with women's increased utilization of hospitals in a nearby town for delivery and related complications. They found that in recent years more and more women from both areas went to hospitals for delivery, especially in cases of complications. They also found that women from villages close to towns where hospitals are located or from those villages that have greater transport facilities were more likely to go to hospitals and therefore had reduced their chances of dying during delivery. These villages were equally from the Treatment and Comparison Areas. It seems that maternal mortality reduction was associated with the increased institutional deliveries that were nearly equal in the two areas.

The Treatment Area is likely to have lower maternal mortality than the Comparison Area for several reasons. Due to higher contraceptive use and fewer unplanned pregnancies the former area is characterized by a lower rate of induced abortion, an important factor associated maternal mortality (Rahman, DaVanzo, and Razzaque, 2001). Also, the abortions that do occur in the Treatment Area tend to use a safer method of abortion; the proportion of abortions done by the relatively safer procedure of menstrual regulation is higher in the Treatment Area than the Comparison Area (DaVanzo et al., 2003). In addition, women in the Treatment Area have greater access to reproductive health services and information, and pregnant women are more likely to get health care. In the period 1996-2002, the majority of pregnant women in the Treatment Area received an antenatal check-up (Razzaque et al. 2005). Since 1987, community-based maternity care services, which have been found to reduce mortality from obstetric causes (Fauveau et al. 1991), have been in place in part of the Treatment Area, and beginning in 1990, these services have been expanded to the remainder of the Treatment Area (Ronsmans et al. 1997). Finally, facility-based maternity care has been in place since 1996 in the Treatment Area (Chowdhury et al. 2006). The reproductive

[1] The best measure of this, and the one we consider in our analyses, is to use pregnancies, rather then live births, as the denominator.

health services in the Comparison Area are similar to those are available in a typical rural sub-district in Bangladesh

In recent years the MCH-FP project made systematic efforts to increase institutional deliveries in the Treatment Area through their sub-centers that are located in the communities. The Community Health Workers (CHWs) disseminate information to pregnant women on the needs for antenatal care and for using health services during pregnancy and delivery. Women who come for antenatal care are further counseled to come to ICDDR,B or other safe-delivery centers for delivery and/or whenever they encounter any problems or complications. ICDDR,B data show that institutional deliveries have increased remarkably in the Treatment Area recently (Chowdhury, Ronsmans, et al. 2006). In the early 1990s only a few of births were delivered in the ICDDR,B sub-centers. Beginning in 1997 the percentage began increasing, and by 2005 it had increased to about 40 percent. (There are no comparable data for the Comparison Area, but it is expected that it was around 5-10 percent during this same period.) All these can have an impact on maternal mortality.

Socioeconomic status and maternal mortality

Very few studies have attempted to systematically examine the association between maternal mortality and the woman's socioeconomic characteristics in Bangladesh. In the past, when health infrastructures were not very developed in rural Bangladesh, when delivery services were not adequately available, when the transportation network was in its infancy, and, moreover, when people were not very conscious about availing themselves of institutional facilities for childbirth, one may expect that maternal mortality may not have been associated with socioeconomic status. Now Bangladesh has made remarkable progress in education, especially women's education, urbanization, and roads and transportation (Caldwell et al., 2000). Increased rural-to-urban movement and migration and mass communication have made people more conscious about using modern facilities for health care. Cash flow has increased with economic improvement associated with more jobs both inside the country and outside. There are more educated women and men who are more likely to be health conscious. The Bangladesh Maternal Health Services and Maternal Mortality Survey 2001 (BMMS) cross-tabulated maternal mortality during 1998-2000 by an economic indicator and woman's education and found no significant association (NIPORT, 2003). However, that study used retrospective data on maternal mortality, which may suffer from under- or misreporting. Alauddin (1986) collected prospective data on pregnancy outcomes and associated mortality over a period of 12 months during 1982-83 in a rural sub-district of Bangladesh and examined the association between maternal mortality and socioeconomic conditions. He observed that better-off families tended to have a higher maternal mortality ratio than others but did not offer an explanation of such a relationship. In a recent study in Matlab it was found that use of skilled obstetric care at home or more skilled facilities is significantly and positively associated with household economic conditions (Chowdhury, Ronsmans, et al., 2006). The investigators noted that the rich-poor gap widened after the introduction of facility-based obstetric care.

Setting, Data, and Methods

This study uses data from the Matlab, typical rural subdistrict of Bangladesh, a poor, traditional country in South Asia. Our data on pregnancies and their outcomes have been collected through the Demographic Surveillance System (DSS) of the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B). The DSS data on the timing of pregnancy outcomes are of very high quality because they have been collected during regular household visits (every two weeks until 1997 and every month since then) by trusted female community health workers (CHWs) (D'Souza, 1981; Van Ginneken et al., 1998).

Since October 1977, half of the DSS area has been exposed to the Maternal Child Health-Family Planning (MCH-FP) intervention of the ICDDR,B, which provides better family planning and health services than the standard government services available to people in the other half of the area, known as the Comparison Area (Van Ginneken et al., 1998; Bhatia, 1983). Married women in the Comparison Area were supposed to (but didn't always) receive the standard visits every two months from female welfare assistants of the government family planning program, who provide counseling and supply pills and condoms. In the Treatment, or MCH-FP, Area, well-trained community health workers (CHWs) visited married women of reproductive age every two weeks to provide counseling about family planning services and to deliver injectables, pills, and condoms at the doorstep. Since 2001, CHWs visit the doorstop only to collect data; they no longer deliver services, and women in the MCH-FP Area must now go to a health center to receive the services. Hence, at least until 2001, the MCH-FP Area was characterised by greater contact among clients, workers, and supervisors as well as greater availability and a broader mix of contraceptive methods than is available in the Comparison Area. In addition to the standard government Health and Family Welfare Centres available in both areas, the MCH-FP Area also has ICDDR,B sub-centres that provide maternal and child health and family planning services that are better than those available in the Comparison Area. Contraceptive use, antenatal care, child immunization, and utilization of other child health services are all substantially greater in the MCH-FP Area than in the Comparison Area (REF). This has resulted in lower fertility and lower infant and child mortality in the former compared to the latter (LeGrand and Phillips, 1996). Rates of induced abortion are lower in the MCH-FP Area than in the Comparison Area (2.2% vs. 4.2%); rates of miscarriage (5.3% vs. 5.8%) and stillbirth (3.0% vs. 3.2%) are also slightly lower for the years 1982-2002 (DaVanzo et al., 2006).

Until the mid-1980s, delivery services were similar in the two areas. Since then, however, they have improved considerably more in the Treatment Area. Since 1987, community-based maternity care services have been in place in part of the Treatment Area, and beginning in 1990, these services were expanded to the remainder of the Treatment Area (Ronsmans et al. 1997). In addition, facility-based maternity care has been in place since 1996 in the Treatment Area (Chowdhury et al. 2006). By contrast, the reproductive health services in the Comparison Area are similar to those are available in a typical rural sub-district in Bangladesh

In addition, in recent years the MCH-FP project made systematic efforts to increase institutional deliveries in the Treatment Area through their sub-centers that are located in the communities. The Community Health Workers (CHWs) disseminate information to pregnant women about the needs for antenatal care and for using health services during pregnancy and delivery. Women who come for antenatal care are further counseled to come to ICDDR,B or other safe-delivery centers for delivery and/or whenever they encounter any problems or complications. ICDDR,B data show that institutional deliveries have increased remarkably in the Treatment Area recently (Chowdhury, Ronsmans, et al. 2006). In the early 1990s only a few of births were delivered in the ICDDR,B sub-centers. The percentage began increasing in 1997, and by 2005 it had increased to about 40 percent. (There are no comparable data for the Comparison Area, but it is expected that it was around 5-10 percent during this same period.) All these can have an impact on maternal mortality.

We analyze maternal mortality for a sample of nearly 140,000 pregnancy outcomes that occurred in the two areas of Matlab during the period 1982-2002.

Maternal mortality

Maternal mortality is the dependent variable in this study. WHO defines a maternal death as "the death of a woman during pregnancy or within 42 days of pregnancy outcome from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes" (REF). To identify maternal deaths in our data, we matched death records with the pregnancy outcomes through the unique identification number in the DSS. We consider all pregnancies recorded in the DSS between 1982 and 2002 except for 3,041 pregnancies that resulted in multiple outcomes (twins and triplets), which we exclude because these outcomes carry a special risk of maternal deaths that should be separately studied.[2]

The cause of death in DSS is classified based on the ICD code recommended by the World Health Organization (WHO). Through regular DSS activities, each death undergoes a verbal autopsy to identify cause of death. A Health Assistant registers in a form each death in the DSS area and describes the signs and symptoms of the deceased prior to death. Other relevant situations that may be related to the death are also described in the form. Based on the description, a trained medical assistant under the supervision of a committee of physicians classifies a death according to the ICD code. During the process of classification, the medical assistant may send the death form to the Health Assistant to collect further information that may help proper diagnosis of the cause of death. Several codes of death are associated with direct or indirect maternal death. This approach of classification of death began in the mid-1990s. Prior to this, DSS had their own codes on causes of death.

Using the ICD classification, we determine whether the death was due to direct or concomitant causes. An example of the former is a death during delivery due to eclampsia, whereas an example of the latter is a death from acute diarrhea or cardiovascular illness during pregnancy or within 42 days of pregnancy. We consider both direct and indirect or concomitant causes in this study.

[2] We consider 167 women who died during pregnancy. We don't know whether any of them were carrying multiple fetuses.

In the DSS, there is little likelihood of underreporting of maternal morality,[3] but there is the possibility of misclassification of cause of death in general and maternal death in particular. To investigate whether there were any misclassifications, a senior project staff member reviewed death forms for all females who were aged 15-49 at the time of death. In order to determine whether a female death is a maternal death, we looked to see if there was a pregnancy outcome or if the deceased was pregnant prior to death. If one of these was found, descriptions of circumstances of the death and signs and symptoms of associated morbidity were further checked and reviewed to see if the classification was properly done.

The final classification of deaths is done by comparing our data with those of three teams of investigators of maternal mortality in Matlab. The classification for the period 1982 through 1987 comes from the study conducted by Koenig and his colleagues (1988). We compared our classification with that of Ronsmans et al. (1988) for the period 1982-1997. Finally, we compare cause-of-death data with those of Dieltiens et al. (2005) for the period of 1990-2001. We confirmed the classification of each maternal death when all teams reached a consensus about it. We consider a total of 444 maternal (both direct and indirect or concomitant) deaths during the period 1982-2002 (Table 1).[4] We exclude 14 accidental deaths that occurred either during pregnancy or within 42 days of pregnancy outcome.

Methods of Analysis

We examine the bivariate relationships between the likelihood of maternal mortality, defined as maternal deaths per 1,000 pregnancies, and various explanatory variables described below. We then estimate a multivariate model of maternal mortality risks using a logistic regression model to examine the net effect of the factors considered; we present the multivariate results as odds ratios.

Independent Variables

In our bivariate analysis we consider how maternal mortality varies with the outcome of the pregnancy under consideration – live birth, stillbirth, miscarriage, or induced abortion.[5] We consider the following demographic factors in our bivariate and multivariate

[3] It is highly unlikely that the death of an adult would not be reported in the Matlab DSS.

[4] There were 167 women who died during pregnancy but do not have a pregnancy outcomes recorded in the DSS for that pregnancy. We included them in our database and collected relevant information on them from various DSS data files.

[5] We do not consider this variable in our multivariate analysis because it is likely to be jointly determined with other explanatory variables we consider. Also, the mother may die *because* the fetus died in utero.

analyses: maternal age at the time of pregnancy outcome (or at death who died during pregnancy), gravidity, the length of the interpregnancy interval (IPI) preceding the pregnancy, and cumulative number of child death(s) and pregnancy loss(es) due to induced abortion, miscarriage or stillbirth the woman experienced prior to the pregnancy in question. These variables are all available in the DSS database. The duration of the interpregnancy interval is defined as the amount of time between the preceding pregnancy outcome and the estimated date of conception of the index pregnancy. The DSS has recorded the date of a woman's last menstrual period, as part of women's reproductive history, since 1978 for the Treatment Area and since 2000 for the Comparison Area. In order to include the interpregnancy interval variable all pregnancies in both areas, we estimated the date of conception under certain plausible assumptions about the duration of a pregnancy depending on its outcome. We calculated the duration of inter-outcome interval (IOI) between the dates of preceding and index pregnancy outcomes in months. We then estimated the interpregnancy interval (IPI) as (IOI – 9) for a live birth, as (IOI – 7) for stillbirths, as (IOI - 4) for miscarriages, and as (IOI – 2) for induced abortions. The analysis also includes variables identifying cases where the duration of the interpregnancy interval is unknown (e.g., because the previous pregnancy occurred before the woman moved to the Matlab area).

We control for the following the socioeconomic factors in both analyses: the woman's education, her husband's education, household economic condition, and, religion. Economic condition is measured by household space, which has been found in Matlab to be associated with mortality and other health indicators (D'Souza et al. 1982).

We consider woman's residence in the Treatment Area as an indicator of programmatic factors. As noted above, since 1977, the Treatment Area has received a number of health care and family planning interventions, including obstetric care.

In the regression model, previous child deaths, previous pregnancy loss, woman's years of schooling, logarithm of household space, and calendar year are treated as continuous variables, because the bivariate analyses suggest that their effects are monotonic. Maternal age, interpregnancy interval, gravidity are included as categorical variables so that we can allow for nonlinear relationships.

Results

There were 344 maternal deaths during 1982-2002 among the 142,592 pregnancies we consider in the Comparison and Treatment Areas of Matlab. About four of five deaths were due to direct causes of maternal mortality (Table 1). Thirty-eight percent of all direct and concomitant deaths occurred during pregnancy; 35 percent occurred within the first week after the pregnancy ended, and 27 percent during 7-42 days of postpartum.

The average likelihood that a woman died from maternal death was 3.11 per 1,000 pregnancies in Matlab during 1982-2002 (Table 2). Maternal mortality ratio was 3.53 per 1,000 live births.[6]

Bivariate Analyses

<u>Pregnancy outcome</u>

Table 2 shows that any of the non-live-birth outcomes, especially stillbirth, carry significantly higher risks of maternal mortality than live births Women with pregnancies that ended in an induced abortion, miscarriage, and stillbirth had risks of maternal mortality that were 4.01, 2.13, and 14.43 times higher, respectively, than women with a live birth. Twelve percent of all pregnancies in our sample ended with a non-live birth (over 3 percent of with an induced abortion, about 6 percent in miscarriage, and another 3 percent in stillbirth). If there were no non-live births in Matlab, maternal mortality could have been 1.22 per 1,000 pregnancies compared to the overall maternal mortality rate of 3.11.

<u>Interpregnancy interval</u>

Table 3 shows the likelihood that a pregnancy will end in a maternal death for first pregnancies and by the duration of the preceding interpregnancy interval for higher-order pregnancies. Mortality risks are two times higher for first pregnancies than for pregnancies that occurred after an interpregnancy interval of 24-59 months (p<0.001). For higher-order pregnancies there is nearly a J-shaped relationship between maternal mortality and the duration of the preceding interpregnancy interval. The lowest probability of maternal mortality is observed for 24-59-month interpregnancy intervals. Compared to interpregnancy

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[6] The total number of live births in our sample is 125,750. Most maternal mortality studies deal with mortality ratio, a ratio of maternal deaths to live births, primarily because either data on other pregnancy outcomes other than live births are not available or they are reported incompletely. Although we focus on the probability that a pregnancy will result in a maternal death – deaths divided by pregnancies – we also compute of the maternal mortality ratio so that we can compare our estimates with those in other studies.

intervals of 27-50 months, risks of maternal mortality are higher for interpregnancy intervals shorter than 27 months, especially for those with intervals less than 6 months. For example, the odds of mortality is 40 percent higher among women who had a conception within six months of the last pregnancy outcome compared to those women who conceived after a period of 27-50 months; however, this difference is not statistically significant. Mortality risks are significantly higher ($p<0.01$) for very long intervals. The risk of maternal mortality is nearly double if women waited for five years or more to conceive compared to having an interpregnancy interval of 24-59 months. Risks are quite similar for women with the first pregnancies (4.38 maternal deaths/1,000 pregnancies) and those whose pregnancies are preceded by an interval of 60 months or more (3.93 maternal deaths/1,000 pregnancies). We also observe that mortality risks are high for women whose previous interval length is unknown ($p<0.01$).

Maternal age and gravidity

In Table 4 we examine mortality rates cross-tabulated by mother's age *and* gravidity (the number of previous pregnancies before the index pregnancy). Both age and gravidity have an almost U-shaped relationship with maternal mortality. Regardless of their age, women with first pregnancies have higher mortality risks than women with 2-6 pregnancies. The mortality risk of women with first pregnancies is comparable to that for women with seven or more pregnancies. In almost all age groups, there is a tendency for mortality to increase with gravidity, though the rate of increase is neither large nor is consistent.

Ages 20-24 appear to be safest ones to have the first pregnancy in Matlab; the risk of maternal mortality for first pregnancies is lowest for this age group. Holding constant gravidity, the risk of maternal mortality generally increases with age beyond age 29. This is especially true for first pregnancies. Women who don't have their first pregnancy until their 30s or 40s may have health problems that both made it more difficult to conceive and increased their risk of maternal mortality.[7] For first pregnancies, teenagers also have higher risks of mortality than women aged 20-29. In the marginal by age, we do see higher risks for teenagers. This reflects the effect of age for first pregnancies as well as the fact that teenagers have a higher incidence of first pregnancies (which have a higher risk of maternal mortality) than older women.

[7] About 1.5% of women had their first pregnancies in their 30s or 40s.

Previous child deaths and pregnancy losses

In Table 5, we examine the relationship between maternal mortality and a woman's previous experience of child deaths and pregnancy loss. Both prior child deaths and pregnancy loss are risk factors for maternal mortality. The likelihood of maternal mortality was 13 percent (not significant [NS]) and 50 percent ($p<0.01$) higher among women who had one and two or more child deaths, respectively, prior to the index pregnancy compared to those with none. Maternal mortality was 58 percent higher ($p<0.01$) among women who had two of more prior pregnancy losses through miscarriage, stillbirths, or induced abortion compared to women with no previous pregnancy losses. Women with only one pregnancy loss do not seem to have higher risk of mortality.

Socioeconomic variables and religion

In Table 6, we observe that maternal mortality is negatively associated with the woman's and her husband's education and with their household space. Women who have 1-5 years of schooling have 15 percent lower mortality risks than their counterparts with no schooling, but the difference is not statistically significant. Women with 6-10 years and 11 or more years of schooling had 40 percent ($p<0.01$) and 52 percent (NS) lower risks of mortality, respectively, than women with no schooling. Similarly, women had 22, 31, and 44 percent lower risks of mortality, respectively, if their husbands have 1-5 years or 6-10 years, or 11 or more years of schooling compared to women whose husbands have no schooling. These differences in mortality are all significant at the 5% level. Women from the "High" household-space group had 27 percent lower mortality than those in the "Low" group ($p<0.05$). Mortality in other household-space groups was similar to that in "Low" group. Non-Muslims, who are mostly Hindu, had 9% higher maternal mortality than Muslims, but this difference is not statistically significant.

Levels and trends over time in the Treatment and Comparison Areas of Matlab

Maternal mortality declined substantially in Matlab over the time period considered, from about 4 deaths per 1,000 pregnancies during 1982-86 to below 2 deaths during 1998-2002 (see Table 7). Likewise, the maternal mortality ratio declined, from 4.5 (per 1,000 live births) during 1982-86 to 2.0 during 1998-2002.

Table 7 shows that the risk of maternal mortality is always lower in the Treatment Area of Matlab than in the Comparison Area, and that it has generally declined in both areas, but the decline was faster in the Treatment Area, especially in the more recent years that we consider. In the Comparison Area, maternal mortality declined from 4.50 per 1,000 pregnancies during 1982-87 to 2.33 per 1,000 during 1998-2002 -- a 48 percent drop. In the Treatment Area over the same period, it declined from 3.35 to 1.11 -- a 67 percent decline. Risks of maternal mortality were 23 percent lower in the Treatment Area than in the Comparison Area during the period 1982-1987. During 1993-97 and 1998-2002, they were 27 and 52 percent lower, respectively. However, during 1988-92 mortality was about 10 percent higher in the Treatment Area than the Comparison Area.

We saw above, in Table 2, that non-live birth outcomes are associated with a much higher risk of maternal mortality. In Table 8 we assess whether the lower maternal mortality in the Treatment Area can be explained by the differences in proportion of pregnancies that end in non-live births. Incidence of abortion was almost half in Treatment Area than the Comparison Area ($p<0.01$). Miscarriage and stillbirth were also significantly lower ($p<0.05$). However, we also find that the maternal mortality risk associated with each of type of non-live-birth pregnancy outcome is lower in the Treatment Area. Table 8 shows that probability of dying was 20 (NS), 35 (NS), and 41 ($p<0.05$) percent lower in the Treatment Area than the Comparison Area for the women whose pregnancies ended with an induced abortion, miscarriage, or stillbirth, respectively. In all, mortality among all women with non-live birth pregnancies was 33 percent lower in the Treatment than those in the Comparison Area ($p<0.05$). By contrast, for those with live birth, maternal mortality was only 2 percent lower (NS) in the treatment Area.

Multivariate Analyses

Table 9 shows odds ratio estimates from our logistic regression model. The relative odds of maternal mortality monotonically increase with age; they are significantly greater for women aged 25 and older compared to those aged 20-24, and they increase especially after age 30. There is no evidence that teenagers have higher risks of maternal mortality than their older counterparts. As mentioned above, the higher mortality observed among teenagers in the bivariate analysis largely reflects the fact that first pregnancies that have high risks of mortality, and most of the pregnancies that occur before age 20 are first pregnancies. (For example, in our data, 77, 33, and 6 percent of pregnancies were first pregnancies in age groups <20, 20-24, and 25-29, respectively.) After controlling for the effects gravidity and other variables, we find that teenagers and 20-24-year-old women have a similar mortality risks.

The odds of maternal mortality risks are 1.69, 2.33, and 3.93 times higher for women aged 25-29, 30-34, and 35-39 compared to those aged 20-24 years. The odds are seven times or higher among women aged 40-49 years relative to those aged 20-24.

Consistent with our bivariate analyses, we do not find any evidence that women are at significantly higher risk of mortality following a short interpregnancy interval and we find that women with interpregnancy intervals of 60 months or more have higher odds of maternal mortality --1.63 times higher ($p< 0.05$) in the multivariate analysis -- compared to those with interpregnancy intervals of 24-59 months.

As in the bivariate analysis, regardless of their age, women with their first pregnancies are at very high risks of mortality: in the logistic regression they have 3.6 times higher odds of death relative to women with their second pregnancy. In our bivariate analysis, mortality risks increased steadily with gravidity, especially after the third pregnancy, and we generally observed similar results within the age groups. The regression results for the gravidity-mortality relationship, however, show that when other variables are controlled, mortality risk *decreases* with gravidity, and women with eight or more previous pregnancies have significantly lower odds of mortality compared to those two pregnancies. A possible explanation of this is offered in the next paragraph.

Similar to what we found in the bivariate analysis, we see in the multivariate analysis that women who had prior child deaths or pregnancy losses have higher risk of maternal mortality; in fact, the effects are even stronger in the multivariate analyses than in the bivariate analyses. The likelihood of maternal mortality increases by 16 percent for one child death prior to the present pregnancy ($p<0.05$) and by 31 percent for one previous pregnancy loss through an induced abortion or miscarriage, or stillbirth ($p<0.001$). This may explain why the effect of high gravidity is different in the multivariate analysis compared to the bivariate analysis. Women with high gravidity have had more opportunity to experience previous pregnancy losses and child deaths. It appears to be these previous adverse outcomes, rather than high gravidity per se, that account for the positive relationship between higher gravidity and maternal mortality that we see in our bivariate analysis.

As in the bivariate analysis, women's education is negatively associated with maternal mortality ($p<0.01$) when other variables are controlled. A four-percent reduction of mortality is observed for each year of schooling. Similarly, mortality is negatively associated with household space, meaning that mortality is lower among the richer than the poorer. As in the bivariate analysis, in the multivariate analysis there are no significant differences of maternal mortality between the Muslims and non-Muslims.

In the multivariate analysis, pregnancies in the Treatment Area have a 26 percent lower odds of maternal mortality than those in the Comparison Area during the study period, 1982-2002 ($p<0.01$).

Maternal mortality in Matlab has been significantly declining since 1982 with a five-percent annual reduction. Because our bivariate analysis showed a greater decline in the Treatment Area than the Comparison Area, we tried an interaction between area and time, but it was not statistically significant in the logistic model (results not shown). When other variables are controlled, the rate of mortality decline is the same for the Treatment and Comparison Areas.

Discussion

We analyze high-quality prospective data from Matlab DSS on maternal mortality among a large number of pregnancies during 1982-2002 to investigate the relationship between demographic, programmatic, and socioeconomic variables and maternal mortality. These data are highly unlikely to suffer from the underreporting usually encountered in on maternal mortality data. Also our data on maternal mortality, coming from frequent prospective data collection in an entire population, rather than, say, only deaths occurring in a hospital or relatives' reports of women's deaths, are likely to cover a more representative sample than those used in many previous studies.

We find that women whose pregnancies end with an induced abortion, miscarriage, or stillbirth, especially stillbirth, have a much higher risk of mortality than those whose pregnancies result in a live birth. If all pregnancies ended in live births, maternal mortality in Matlab could have been 1.22 per 1,000 pregnancies, which is about 60 percent lower than the observed rate of 3.11. We also find that about 40 percent of maternal deaths occurred *during* pregnancy.

The findings of the very high risks of mortality associated with non-live birth outcomes and during pregnancy have strong programmatic implications, especially for antenatal care and delivery management. In Matlab, Bangladesh, about 15 percent of pregnancies during 2004 ended in non-live births (ICDDR,B 2006). Greater access to antenatal care can help reduce miscarriage and stillbirth and thus maternal mortality. Regarding exceedingly high risk of mortality following a stillbirth, it should be noted that many full-term pregnancies can result in stillbirth in Bangladesh because most deliveries take place at home, many complicated pregnancies need emergency medical interventions are not at all taken to hospitals or taken late. Such cases may end up with stillbirth as well as maternal mortality. The same is true for deaths during pregnancies before there is a pregnancy outcome. Increased coverage and enhanced quality of antenatal services can help identify such high-risk women and refer them to higher-level providers and/or facilities. Better access to both antenatal care and institutional deliveries can thus lead to lower maternal mortality. In addition, prevention of unintended pregnancies by increased and effective use of contraceptive can reduce the incidence of induced abortion and thus maternal mortality.

We investigated the association between four demographic factors and maternal mortality. Specifically, we assessed the effect on maternal mortality of four "too's that are commonly believed to be associated with maternal mortality -- *too young* motherhood, *too closely spaced* births, having *too many* births, and *too old* motherhood. We find that only one "too" -- too old -- is associated with an increased risk of maternal mortality. Pregnancies among teenage women, after short intervals, or to women already having many children do not have excessive risk of maternal mortality.

It has been asserted that births that are "too" closely spaced carry a risk both for the child's and mother's health mainly through hypothesized maternal depletion syndrome in which it is believed that it takes a reasonable amount of time for a woman to recover from the physiological stresses associated with the previous pregnancy (e.g., Khan et al., 1998; Miller, 1991; Winikoff, 1983; and Winkvist et al., 1992). Some studies have documented through a bivariate analysis that short intervals are risk factors for maternal mortality (e.g., Anandalakshmy et al., 1993; Miller et al., 1992; and Winikoff, 1983). Conde-Agudelo and Belizán (2000), in a study of pregnancies in Latin America, showed that maternal mortality was 2.5 times higher among women who had an interpregnancy interval of less than six months than among women having an interpregnancy interval of 18-23 months, after controlling for the effects of maternal age, gravidity, body mass index before pregnancy, history of miscarriage, marital status, education, and smoking habits. Conde-Agudelo and

Belizán also find that eclampsia, third-trimester bleeding, premature rupture of membranes, puerperal endometritis, and anemia were significantly higher among women who had an interpregnancy interval of less than six months than for women who had an interval of 18-23 months. And in companion studies we show that pre-eclampsia and high blood pressure are more likely in Matlab for women with preceding interpregnancy intervals of less than six months compared to those with intervals of 27-50 months (Razzaque et al. 2004) and that short intervals increased the risk of infant mortality (DaVanzo et al. 2005) and adverse pregnancy outcomes (DaVanzo et al, 2006). Nonetheless, our finding of no significant relationship between short intervals and maternal mortality is consistent with what was found in Matlab by Ronsmans and Campbell (1998).

We find a new "too" -- too long pregnancy intervals have a higher risk of maternal mortality. We find that interpregnancy intervals of 60 months or longer (equivalent to an interbirth interval of almost six or more years for full-term pregnancies) are associated with significantly ($p<0.05$) increased in risk of maternal mortality. When other variables are controlled, the odds of maternal mortality are over 60 percent higher for such long intervals compared to interpregnancy intervals of 24 to 59 months. The higher risk of maternal mortality we find for very long intervals is consistent with Conde-Agudelo and Belizán's (2000) finding in Latin America that interpregnancy intervals of 60 months or longer are associated with higher levels of pre-eclampsia, eclampsia, and third-trimester bleeding. In analyses of maternal morbidity in Matlab (Razzaque et al. 2005) during the period 1995-2002, we found that the incidence of pre-eclampsia and high blood pressure was around two times ($p<0.01$) higher among women with interpregnancy intervals of 75 or more months than those with 27-50 month intervals. Based on our findings, a message to women who have already been pregnant before and want to be pregnant again may be that, for the sake of their own health, they should not wait for more than six years to become pregnant again. If women do become pregnant after such a long interval, they should be carefully monitored.

However, it is possible that this effect is not really a causal effect of long intervals, but instead that a long interval is itself a reflection of poor maternal health. A woman in poor health may have difficulty becoming pregnant, and this may lead to a very long interpregnancy interval. The incidences of malnutrition, anemia, reproductive tract infections, and other maternal morbidities, alone or in combination with other illnesses, are high in Bangladesh (REF), as they are in many developing countries. It is possible that women with these conditions are sub-fecund and take a long time to conceive. Some studies (not ours, however) have observed an elevated risk of infant and child mortality for such long intervals. This might also be explained by such a health-effect mechanism. In our data, about eight percent of all pregnancies occurred after interpregnancy intervals of 60 or more months. Further research is needed to investigate whether there is a relationship between long interpregnancy intervals and health conditions.

It is widely believed in the field of reproductive health that, because a girl continues to grow physiologically and mentally until age 20 and beyond, her physiology is not yet fully ready to bear a child before this age and thus teenage motherhood will detrimental, including being associated with higher risks of maternal mortality and infant and child mortality. In developing countries where childbearing often takes place at early age, it is often found, in the bivariate relationship, that both maternal mortality and infant and child mortality are high among mothers under age 20 than others (REF).

With prospective good-quality data with large sample size, we find that this is not the case for maternal mortality in Matlab when we control for the influences of other factors. In our study, the risk of maternal mortality is similar among teenagers and women aged 20-24 years, once the effects of gravidity and other variables are controlled for. The relationship observed in a bivariate analysis is confounded by the fact that pregnancies at a young age are likely to be first pregnancies, and first pregnancies have higher risks for maternal mortality. Furthermore, research on the United States that controls the effects of socioeconomic, behavioral, familial, and environmental factors shows that teenagers do not experience greater risks of maternal mortality than older women. It is argued that it is not the young mother's biology but the other (e.g., socioeconomic) factors that lead to higher risks of childbearing (REF). Our companion study of maternal morbidity (Razzaque et al. 2005) finds that teenage women had significantly lower incidences of pre-eclampsia and hypertension than older women. Our companion study of infant and child mortality (DaVanzo et al., 2004) finds that the detrimental effect of teenage motherhood is limited to the first year of a child's life.

We find that maternal mortality risk increases sharply with age after age 30. This has strong programmatic implications for Bangladesh. Because of early marriage and childbearing, most women achieve their desired family size, which averages 2.5 children, before age 30. During the ages 30-49, women on average end up with about one excess child. This is mainly due to inadequate accessibility to contraception. Contraceptive method choice in Bangladesh is heavily skewed towards spacing methods like pills, injectables, and condoms and traditional methods. Women who have already achieved their desired family size continue to use these spacing methods, which have high rates of use-failure and discontinuation associated with side effects. Permanent contraceptive methods or longer-term methods that are appropriate for limiting fertility are, unfortunately, not popular in Bangladesh. Many women thus encounter unintended pregnancies. Some abort their pregnancies, and others end up with a live birth leading to excess births. In other research, we show that abortion sharply increases with women's age (Rahman, DaVanzo, and Razzaque, 2004). Strong family planning behavior change communication (BCC) activities coupled with quality services should be designed to have a balanced contraceptive method mix in which more and more couples will adopt permanent and longer-term methods for limiting purposes. This can help reduce the incidence of childbearing beyond age 30 and thus reduced maternal mortality.

We find that first pregnancies carry an extra health risk for women. Typically, reproductive health counseling emphasizes delayed childbearing beyond teenage on health grounds. Our analysis shows that mortality is found to be high among teenagers because most of them have the first pregnancy in this age range. First pregnancy is the real risk factor. Mothers with first pregnancies should be counseled on the risk of mortality and they should also be monitored. Older women who are pregnant for the first time have particularly high risk and should be carefully monitored.

We find that women who have experienced child deaths and pregnancy losses (abortion, miscarriage, or stillbirth) are at higher risks of maternal mortality, and the fact that such women tend to be of higher gravidity explains why we saw higher rates of maternal mortality at higher gravidities in our bivariate analysis, but not in our multivariate analysis. Women who have experienced child deaths and pregnancy losses should be monitored when pregnant. Prior child deaths or pregnancy losses are likely to be correlated with woman's own health status, her health-related behavior, family environment, and other aspects that influence the overall health of a woman and her children and can provide a proxy for such risk factors.

We find in both our bivariate and multivariate analyses that the Treatment Area has significantly lower maternal mortality (whether measured in terms of ratio of deaths to pregnancies or live births or women) than the Comparison Area over the 1982-2002 period considered here. This is in contrast to the findings of other studies that the level of maternal mortality is similar in the two areas (Koenig et al. 1988; Maine et al. 1996; Ronsmans et al. 1999). The lower mortality in the Treatment Area is attributable in part to the area's lower rate of induced abortion, particularly its much lower rate of unsafe abortion, and its lower rate of stillbirths and miscarriages. Furthermore, we find that women whose pregnancies ended in induced abortion, miscarriage, and stillbirth experience lower risks of maternal death in the Treatment than Comparison Area, suggesting that the former area's maternity-care program has been able to effectively manage non-live birth pregnancies, especially stillbirths. Also, women in the Treatment area are more likely to use antenatal care and maternity services, both at home and hospitals. About 40 percent of deliveries in the Treatment Area took place in ICDDR,B hospitals in recent years, which can tackle complications, provide caesarian sections, and have a strong referral system to higher-level facilities. In contrast, hospital delivery is much less common in the Comparison Area. The lower incidence of non-live birth in the Treatment Area and the area's lower risk of mortality in non-live birth pregnancies have synergistically helped to reduce mortality in the Treatment Area.

An implication of the finding that increased institutional deliveries help to reduce maternal mortality is that institutional deliveries should be promoted to reduce maternal mortality in Bangladesh. Bangladesh has a large government-managed health infrastructure. The infrastructure includes many facilities that provide deliveries, and are well equipped to manage pregnancy complications and perform caesarian sections. All 64 districts of the country have emergency obstetric care facilities; there are a number of other special facilities for emergency obstetric care; and there are a number of teaching hospitals. There are over 400 Thana Health Complexes at the sub-district level that provide delivery and complications management but without facilities of caesarian section. However, there is a system of referral from sub-district to district level that inhibits use of these facilities. Numerous private clinics have been established in recent years around the country that provide deliveries including caesarian sections. Unfortunately, less than 10 percent of deliveries in Bangladesh take place in such facilities, and many facilities are underutilized. A strong behavior change communication (BCC) program can promote the idea of giving birth at a hospital. People have now greater mobility between village and town; road networks and transport have greatly increased; health consciousness is steadily increasing through increased education and mass media; women's education is increasing dramatically; and, moreover, economic conditions are steadily improving. All these can synergistically increase institutional deliveries in Bangladesh if an appropriate BCC program can be launched effectively. In rural Bangladesh, some NGOs undertake innovative BCC approaches by raising community awareness on the need of institutional deliveries and facilitating the availability of community funds to cover hospital costs and by arranging transportation of pregnant mothers to hospitals. This has increased institutional deliveries of complicated cases. NGO Service Delivery Program's partner NGOs that provide essential health services are replicating these approaches in their catchment communities.

Most women in Bangladesh, especially in rural areas, prefer to deliver a child at home. An effort is being made through pilot schemes of the Government and NGOs to provide safe delivery services at homes by well- trained skilled birth attendants (SBA). SBAs go to clients' homes on call and provide normal deliveries, stabilize the patients in case of complications, and refer those complicated cases that need higher level services. Utilization of effective referral services of complicated pregnancies can help reduce maternal mortality.

We find a significant negative association between maternal mortality on the one hand and maternal education and socioeconomic conditions on the other. This is a new finding in Bangladesh. No previous studies found such a relationship, perhaps because in the past, even if people from higher socioeconomic groups wanted to have institutional deliveries, they could not do it because of unavailability of facilities or lack of transportation to go to facilities. The situations have noticeably improved in recent years. We find that women who are educated, or whose husbands are educated, or women from richer families are now less likely to die from pregnancy or child birth. Socioeconomic conditions, especially education of women, are improving rapidly. It is expected maternal mortality will continue to decline further due to socioeconomic improvement. BCC activities can help to increase women's understanding of the benefits of institutional deliveries.

Greater utilization of maternal health services by the more advantaged groups is likely to increase the inequality of health conditions even further. In fact, investigators have noted that the rich-poor gap widened after the introduction of facility-based obstetric care in Matlab (Chowdhury et al. 2005). An effective safety-net system for improving the health of the poor and the illiterate is needed to help sustain maternal mortality reduction. The Bangladesh government, for example, is currently undertaking a pilot scheme that will distribute maternity vouchers that would enable poor women to have deliveries at hospitals. Implementation of such a scheme through carefully designed and well supervised management system should help reduce the high-levels of maternal mortality in Bangladesh.

We also find, like previous studies, that maternal mortality has been declining equally in both areas.

In sum, in order to maintain and perhaps accelerate the pace of the decline maternal mortality in Bangladesh, reproductive health strategies may include counseling and monitoring of women with first pregnancies, women aged 30 years or over, or women with birth intervals of six years or more. Economic improvement, increased women's education, growing road networks, increased access to information safe delivery, and increased access to safe and institutional deliveries have helped all maternal mortality decrease. These indicators are continuing to improve in Bangladesh, which bodes well for a continued and perhaps accelerated decline in maternal mortality in the future.

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Table 1. Maternal deaths by whether occurred during pregnancy or afterward and by cause of death, Matlab, 1982-2002

Time of death	Direct causes		Concomitant causes		Total	
	Number	%	Number	%	Number	%
During pregnancy	121	34	46	54	167	38
0-6 days after delivery	146	41	11	13	157	35
7-42 days after delivery	92	26	28	33	120	27
Total	359	100	85	100	444	100

Table 2. Likelihood of maternal death (deaths per 1,000 pregnancies) by type of pregnancy outcome

Outcome	Deaths/1,000 pregnancies	Odds ratio	Number of outcomes
Induced abortion	4.89	4.01***	4,701 (3.3%)
Miscarriage	2.61	2.13**	8,047 (5.6%)
Stillbirth	17.39	14.43***	4,313 (3.0%)
Live birth (RC)	1.22	1.00	125,720 (87.9%)
Died during pregnancy	--	--	167 (0.1%)
All	3.11	--	142,952† (99.9%)

RC = Reference category for odds ratios.

†There are 4 maternal deaths whose pregnancy outcomes could not be determined.

** = p<0.01 and *** = p<0.001.

Table 3. Likelihood of maternal death (deaths per 1,000 pregnancies) by the duration of the preceding interpregnancy interval, Matlab, 1982-2002

Interval	Likelihood	Odds ratio	Number of pregnancies
First pregnancy	4.38	2.03***	33,342
<12 months	2.25	1.17	9,906
12-23	2.45	1.13	24,936
24-59 (RC)	2.17	1.00	38,786
60+	3.93	1.82**	8,902
Missing interval	3.43	1.59**	27,080
All	3.11	--	142,952

RC = Reference category for the odds ratios.
* = p<0.05; ** = p<0.01; and ** = p<0.001

Table 4. Likelihood of maternal death (deaths per 1,000 pregnancies) by age and gravidity, Matlab, 1982-2002

Age	Gravidity									
	1	2 (RC)	3	4	5-6	7-8	9-10	11+	All	Odds ratio
<18	3.45 (4,921)	1.59 (629)	- (117)	- (24)	- (7)				3.16 (5,698)	1.30
18-19	5.15 (9,903)	1.03 (2,915)	- (538)	- (115)	- (34)	- (4)	- (1)		4.00 (13,510)	1.64**
20-24 (RC)	3.45 (15,649)	2.13 (16,889)	1.69 (9,459)	1.11 (3,614)	3.56 (1,403)	0.00 (100)	- (6)		2.44 (47,120)	1.00
25-29	6.22 (2,413)	1.72 (6,412)	2.35 (9,804)	1.90 (8,944)	3.17 (8,831)	4.02 (1,492)	0.00 (151)	(18)	2.63 (38,065)	1.08
30-34	16.22 (370)	1.92 (1,040)	2.27 (2,638)	5.09 (4,123)	1.93 (8,797)	3.90 (4,876)	0.83 (1,205)	0.00 (190)	3.10 (23,239)	1.27
35-49	34.88 (86)	0.00 (155)	4.24 (472)	6.44 (932)	4.80 (3,545)	6.15 (4,713)	5.84 (3,424)	4.01 (1,993)	5.55 (15,320)	2.28***
All	4.38 (33,342)	1.89 (28,040)	2.04 (23,028)	2.70 (17,752)	2.96 (22,617)	4.83 (11,185)	4.39 (4,787)	3.63 (2,201)	3.11 (142,952)	-
Odds ratio	2.32***	1.00	1.08	1.43	1.57*	2.56***	2.33**	1.93	-	

Numbers of pregnancies are shown in the parentheses. Mortality likelihoods are not presented for cells where the number of pregnancies is less than 50.
RC = Reference category for the odds ratios in the marginals.

* = p<0.05; ** = p<0.01; and ** = p<0.001

Table 5. Likelihood of maternal death (deaths per 1,000 pregnancies) by the numbers of previous child deaths and pregnancy losses, Matlab, 1982-2002

Factors	Probability	Odds ratio	Number of pregnancies
Prior child deaths			
None (RC)	2.89	1.00	101,698
1	3.28	1.13	27,170
2 or more	4.33	1.50**	14,084
All	3.11	--	142,952
Prior pregnancy losses			
None (RC)	3.00	1.00	112,187
1	3.13	1.05	22,692
2 or more	4.71	1.58**	8,071
All	3.11	--	142,950

RC = Reference category for the odds ratios.

+ = p<0.10 and ** = p<0.01.

Table 6. Likelihood of maternal death (deaths per 1,000 pregnancies) by socioeconomic and programmatic factors, Matlab, 1982-2002

Factors	Deaths/1,000 pregnancies	Odds ratio	Number of pregnancies
Woman's education			
No schooling (RC)	3.52	1.00	73,789
1-5 years of schooling	3.01	0.85	43,500
6-10 years of schooling	2.10	0.60**	23,284
11+ years of schooling	1.68	0.48	2,379
All	3.11	-	142,952
Husband's education			
No schooling (RC)	3.61	1.00	69,182
1-5 years of schooling	2.81	0.78*	42000
6-10 years of schooling	2.49	0.69**	24,869
11+ years of schooling	2.03	0.56*	6,901
All	3.11		142,952
Household space			
Low (<170 sq. ft.) (RC)	3.31	1.00	38,708
Low – Medium (170-249 sq. ft.)	3.00	0.99	35,113
Medium (250-349 sq. ft.)	3.34	1.00	33,530
High (350 + sq. ft.)	2.43	0.73*	35,366
All	3.09		142,717
Religion			
Muslim (RC)	3.08	1.00	127,430
Non-Muslim	3.11	1.09	15,522
All			142,952
Area			
Comparison (RC)	3.47	1.00	77,500
Treatment	2.67	0.77**	65,452
All	3.11		142,952

RC = Reference category for the odds ratios.

+ = p<0.10; * = p<0.05; and ** = p<0.01.

Table 7. Likelihood of maternal death (deaths per 1,000 pregnancies) by calendar year and area, Matlab, 1982-2002

Time	Comparison Area			Treatment Area			Both Areas		
	Likeli-hood	Odds ratio	# Pregs.	Likeli-hood	Odds ratio	# Pregs.	Likeli-hood	Odds ratio	# Pregs.
1982-1987 (RC)	4.50	1.00	24,024	3.35	1.00	19,988	3.98	1.00	44,012
1988-1992	2.91	0.65**	19,922	3.22	0.96	15,824	3.05	0.77*	35,746
1993-1997	3.85	0.86	16,352	2.80	0.84	14,277	3.36	0.85	30,629
1998-2002	2.33	0.52***	17,202	1.11	0.33***	15,363	1.75	0.44***	32,565
All	3.47	-	77,500	2.67	-	65,452	3.11	-	142,952

RC = Reference category for the odds ratios.

+ = p<0.10; * = p<0.05; ** = p<0.01; and *** = p<0.001.

Table 8. Distribution of pregnancy outcomes, deaths, and likelihood of dying (per 1,000 pregnancies), by outcome and area

Outcomes	Number (and %) of outcome			Deaths per 1,000 outcomes		
	Comparison (C)	Treatment (T)	T/C	C	T	T/C
Induced abortion	3,263 (4.2)	1,438 (2.2)	0.52**	5.21	4.17	0.80
Miscarriage	4,563 (5.9)	3,484 (5.3)	0.90*	3.07	2.01	0.65
Stillbirth	2,405 (3.1)	1,908 (2.9)	0.94*	21.21	12.58	0.59*
Live birth	67,165 (86.7)	58,555 (89.5)	1.03	1.24	1.21	0.98
Death during pregnancy	102 (0.1)	65 (0.1)	--	--	--	--
All	99.9	99.9	--	3.47	2.67	0.77

* = p<0.05 and ** = p<0.01.

Table 9. Logistic regression estimates of odds ratios of factors associated with maternal mortality, Matlab, 1982-2002 (n=142,952)

Factors	Relative odds	
Maternal age		
<18	0.72	
19-18	1.04	
20-24 (RC)	1.00	
25-29	1.69	**
30-34	2.33	***
35-39	3.93	***
40-44	7.30	***
45-49	7.52	***
Interpregnancy interval		
<12 months	1.14	
12-23 months	1.11	
24-59 months (RC)	1.00	
60+ months	1.63	*
Missing data on interval length	1.12	
Gravidity		
First pregnancy	3.61	***
2 (RC)	1.00	
3-4	0.78	
5-7	0.61	*
8+	0.25	***
Number of prior child deaths	1.16	*
Number of prior pregnancy losses	1.31	***
Woman's years of schooling	0.96	**
Log of household space	0.96	*
Religion		
Muslim (RC)	1.00	
Non-Muslim	1.12	
Study area		
Comparison (RC)	1.00	
Treatment	0.74	**
Calendar year	0.95	***
Model constant	-5.57	
-2 Log likelihood	6492.16	

RC = Reference category for the odds ratios.
+ = P< 0.10; * = P< 0.05; **= p<0.01; and *** = p<0.001.