The Short and Long-Term Effects of Reproduction on Mortality: Evidence from Matlab, Bangladesh[1]

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The high risks of childbearing-related health problems experienced by women in the developing world are well known. Maternal disorders, according to Murray and Lopez (1997), are estimated to account for 2.4% of Disability Adjusted Life Years in developing countries and only 0.6% in developed countries. The maternal mortality ratio (pregnancy-related deaths per 100,000 live births) in the mid-1980s was only 10 to 15 in the U.S. (Rosenfield 1989), but about 500 in Matlab, Bangladesh (this figure corresponds to an annual death rate of 100 per 100,000 reproductive-age women) (Fauveau et al. 1988; Koenig et al. 1988). The higher risks are due not only to higher risks per pregnancy but to the higher fertility of women in developing countries, which leads to greater lifetime exposure to the risk of maternal mortality. They lead to estimates by the National

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Research Council (1997) of lifetime risk of maternal mortality of 1/48 for women in the developing world compared to 1/1800 for women in the developed world.

In addition to mortality around the time of childbirth, there are several hypotheses relating reproduction to survival. The first is cumulative exposure -- that women who have more children are more likely to experience high morbidity, which may, over time, lead to poor health and increased mortality. The second is nutritional - that women in the developing world may suffer from maternal depletion syndrome as the result of childbearing without sufficient time between births for recovery, or *repletion*, which may affect their overall health and survival. The more rapidly, therefore, a woman has her children, the greater the risks to her health. Fourth is the hypothesis that childbearing or its timing changes risks of conditions that may affect health and survival - positively or negatively. Finally, a positive effect is postulated by the long-held notion that older women are better off if they have had more children (especially sons), simply because there are more sources of support in old age.

Two unusual sets of data on adult women in rural Bangladesh permit examination of their survival longitudinally and prospectively over a 20-year period and, in part, of these hypotheses. This is the second in a series of papers that examine, first, survival of these women as a function of their early life conditions and, here, of fertility, over a 20-year period.

BACKGROUND

The first dataset is from the Determinants of Natural Fertility Study (DNFS) sponsored by the International Centre for Diarrhoeal Disease Research, Bangladesh, now the Centre for Health and Population Research, ICDDR,B. The DNFS collected detailed information over about a three-year period beginning in the late 1970s from a group of 2441 women. Studies based on these data have contributed to knowledge of reproductive events, the effects of malnutrition on conception rates and spontaneous abortion, the role of lactation in postponing conception, maternal weight changes during and after pregnancy and maternal depletion (c.f. Chowdhury and Becker 1981; Huffman et al. 1987; Ford et al. 1989; Pebley et al. 1985; John, Menken and Chowdhury 1987; Ford and Huffman 1993; Miller, Rodriguez, and Pebley 1994). During and subsequent to the DNFS, information on these women was collected on a regular basis as part of ICDDR,B=s Demographic Surveillance System (DSS). The second data consists of information on death, outmigration, and childbirth subsequent to the DNFS through 1996 that we extracted by searching the yearly files on births, deaths, and migration for records pertaining to the DNFS women.

The data are unique in several ways. Accurate measures of both deaths and births over a long period of time are a rarity for developing countries. They permit us to consider both the immediate and long-term relationships between childbirth and mortality. The DNFS recorded two measures of health in childhood and relatively early adulthood. Based on earlier research that failed to find a relationship between parity and survival, investigators have suggested that two counterbalancing processes may have been at work -- that women already in poor health had fewer children and that those who were healthier had more children, leading to poorer health, so that no parity relationship was observed (Mitra et al. 1997). Height is a generally accepted proxy measure of health in childhood. It reflects health status prior to the beginning of the reproductive period (except, to some degree, for those women who experienced their first birth before they had achieved their adult height), so that it can be included in our analyses to control for possible endogeneity of health and reproductive behavior. A woman=s weight was recorded close to her entry into the DNFS and, usually, multiple times over the course of the study. We include body mass index (BMI = weight/height^2), a commonly-used indicator of recent nutritional deprivation and possible health problems (WHO 1995), as a measure of health status relatively early in adulthood. We note that a woman=s BMI may also have been affected by her earlier reproductive events.

Our earlier results support other work documenting a relationship between early life conditions and later health and survival (c.f. Elo and Preston 1992; Fogel 1994; Lundberg 1993). They indicate that survival over the 20-year followup period is significantly related to early socioeconomic status, as measured by religion, in that Hindus had higher mortality, and by the woman=s own schooling, in that those with no schooling had higher mortality than those who had attended school, no matter how briefly (Duffy and Menken, 1998; Duffy 2000). At ages under 55, the shortest women (first quartile of height) had increased mortality risk. In addition, a woman=s BMI, measured close to the start of the followup period, was a significant predictor of her survival, in that the higher the BMI, the lower the risk of dying. Somewhat to our surprise, higher BMI was protective over the entire 20-year followup period, with no diminution in its effect.

The followup period for this study is especially interesting in that both fertility and mortality were declining rapidly. The TFR was 6.7 in 1977 but dropped by 1996 to approximately 3.5. Female life expectancy improved dramatically - from 51 in 1977 to 65 in 1996; however, female life expectancy at age 15 increased by much less B from 53 in 1977 to 57 in 1996 (Samad et al. 1979; Mostafa et al. 1998). Indeed, our earlier analysis showed that time period was not a significant predictor of survival (Duffy and Menken, 1998; Duffy, 2000).

Questions to be addressed

Does mortality risk depend upon a woman=s parity?: A number of studies have focuses on comparison of nulliparous and parous women=s health and survival, with mixed results (c.f. Strauss et al. 1993; Rahman et al. 1994; Beral 1985; Green, Beral, and Moser 1988; Lund, Arnesen, and Borgan 1990; Kvale, Heuch, and Nilssen 1994; Qureshi et al. 1997). However, among elderly Danish female twins born during the 20th century, parity was negatively related to the number of teeth retained (Christensen et al. 1998). There was a U-shaped relationship between parity and longevity in a study of 8th-to-mid-19th century British aristocracy; however, among women who survived their reproductive years, parity was negatively associated with longevity (Westendorp and Kirkwood 1998).

In much of the developing world, poorer, less educated women have higher fertility. Thus an observed relationship with parity may be the result of the known higher mortality risks among the disadvantaged. But each birth may carry with it a greater increase in risk for disadvantaged women compared to their better-off peers - they may be more likely to give birth under poor sanitary conditions; they have fewer resources (food, access to health care) that might be dedicated to preserving their own health and nutritional status - and these resources could decrease with each additional child, as the number having some claim to family resources increases. We will model parity both linearly and as curvilinearly and introduce interactions with socioeconomic status and early health to test for relationships between the number of children a woman has born and her survival.

Does a woman=s survival depend upon the pace of her childbearing? According to the maternal depletion hypothesis, frequent, closely spaced pregnancies associated with extended periods of intense lactation can lead to inadequate recuperative intervals (non-pregnant, non-lactating or less intense lactation periods) between pregnancies. Both pregnancy and lactation considerably increase energy expenditure and, if a woman cannot compensate, her nutritional status and health may decline, especially if this cycle continues over successive pregnancies (c.f. Adair and Popkin 1992; Merchant and Martorell 1988; Miller, Rodriguez, and Pebley 1994). But the evidence for the existence and extent of maternal depletion in developing country populations is quite mixed. In fact, a number of studies show a positive relation between a woman=s parity and her nutritional status (Miller and Huss-Ashmore 1989; Adair and Popkin 1992, Pebley and DaVanzo, 1993). Women who are undernourished at conception can actually gain weight during pregnancy and lactation (Winkvist et al. 1994; Merchant and Martorell 1988). Miller, Rodriguez, and Pebley=s (1994) analysis of the DNFS provides some contradictory evidence. Controlling for maternal age, not only did weight decrease with parity, but women lost weight for 16 months following the delivery of a live birth, with some evidence of weight gain thereafter. The longitudinal followup period was too short to determine the extent of subsequent weight gain. However, cross-sectional analysis, which included women at longer durations postpartum, found that those with longer interpregnancy intervals tended to weigh more, suggesting that, even in this poorly nourished population, women may be able to replete. Bolstering this conclusion is a case-control study in Matlab, Bangladesh, which found that short birth intervals per se were not responsible for higher rates of maternal mortality (Ronsmans and Campbell 1998).

Direct information on lactation was collected only during the DNFS period, and only too few deaths occurred before 1980 for mortality analysis. Therefore, we use a measure of a woman=s pace of childbearing, calculated, following Boulier and Rosenzweig (1978), as the ratio of the number of children she has born by a particular age relative to the number predicted for a woman her age from the 1979 Matlab age-specific fertility rates (Chowdhury et al. 1982)

For how long after a birth is a woman subject to higher mortality? The causes of maternal mortality are conventionally divided into direct causes (that occur only during pregnancy and the immediate post-delivery period) and indirect causes (from conditions that already exist but are aggravated by the pregnancy. In the developing world, direct causes account for 75-80% of maternal mortality and most can be attributed to just three causes: hemorrhage, sepsis, and eclampsia (Menken and Rahman 2001). High mortality is accompanied by high morbidity. AIt is estimated that between 30-40 percent of the approximately 180 million women who are pregnant annually in the world, or roughly 54 million women, report some kind of pregnancy-related morbidity annually. Of these, it is estimated that about 15 million a year develop relatively long-term disabilities deriving from complications@ (Menken and Rahman 2001). Based on these considerations, we expect that mortality will be elevated shortly after a birth. But due to the high rates of pregnancy-related morbidities, we will investigate whether mortality remains elevated for longer periods. Unfortunately, we cannot gauge the full extent of mortality related to pregnancy and childbirth since information is limited to live births.

Is timing of births, as measured through age at first or last birth, related to mortality? Timing of first and last birth may also affect health and longevity. In Bangladesh, childbirth significantly delayed growth among adolescents (Riley 1990; 1994). Very young mothers have greater risks of complications during delivery. Several studies find that women who gave birth early (before 20) had lower life expectancy (Westendorp and Kirkwood 1998) or that the relationship is U-shaped, with women who gave birth early or late (after reaching age 40) having higher mortality risks (Doblhammer and Vaupel, 1997).

Other studies have found that women who have a child late (after 40) lived significantly longer than women who had their last child earlier. Centenarians were four times more likely to have had children while in their forties compared to women with similar characteristics who survived only to age 72 (Perls, Alpert, and Fretts 1997). Women who reach menopause late have also been found to have lower mortality risks (Snowdon et al. 1989). Suggested mechanisms are mainly biological, in that if reproductive aging is correlated with aging of other organ systems, a late birth or late menopause may be an indicator of overall slow aging. Social factors may also play a role. For example, in their later years, women may benefit more from support of younger children than older children (Doblhammer and Vaupel 1997; Westendorp and Kirkwood 1998).

The accuracy of DNFS data on age at first birth is questionable (Duffy 2000). Therefore, we can only examine the effects of age at last birth and do so among the group of women who competed childbearing (i.e. reached age 55) during the followup period.

Do older women benefit from having had high fertility? During old age, women may receive material and non-material support from their children and may have greater ties to the community as the result of having children (Spitze and Logan 1990; Soldo, Wolfe, and Agree 1990). Such support is even more important in developing country societies, where the elderly are often heavily dependent upon their children, particularly sons, socially and financially (Rahman 1999a; 1999b; Rahman, Foster, and Menken 1992). But high parity may also be associated with higher mortality risks during adulthood and old age, although results are mixed, with some studies (Lund, Arnesen, and Borgan 1988) finding higher rates for women of parity five and higher, and others (Green, Beral, and Moser 1990) not conclusive. Possible mechanisms for a positive association between parity and mortality at older ages include greater stress associated with having many children, biological factors (e.g. cumulative maternal depletion or illnesses directly related to pregnancy and childbearing), and social factors (e.g. isolation from non-familial social networks associated with having a relatively large family (Ness et al. 1993), although this factor may be more relevant in developed country contexts.

DATA AND METHODS

The Determinants of Natural Fertility Study (DNFS) was conducted in 14 villages now within the comparison area of the ICDDR,B Maternal and Child Health-Family Planning (MCH-FP) Programme. The DNFS was designed to measure the relationship between health and reproductive performance in a population with low levels of contraceptive use. Between January 1975 and August 1979, all 2,441 married, fecund women, (i.e., those who were neither sterilized nor menopausal) who resided in the target villages were followed prospectively for three years (on average) on a monthly basis. They ranged in age from 11 to 50 at the start of observation. Detailed information was collected on each woman=s reproductive status (breastfeeding, menstruation, pregnancies and their terminations, births, etc.), her health and nutritional status (as measured by height and BMI and some blood testing), and the health of her children. Limited information on socioeconomic status (e.g., schooling, religious affiliation, husband=s occupation) was also obtained at entry (Chowdhury and Becker 1981).

Subsequently, these women were followed by the Matlab Demographic Surveillance System (DSS), which collected information at least monthly on vital events (births, deaths, marriages, divorces, inmigrations, outmigrations) experienced by all individuals living in the area. We extracted DSS data pertaining to deaths and outmigration of the DNFS women and the births of their children through 1996.

Person-year observations were created for each woman who had her height and weight measured in the DNFS. There is a person-year observation for each calendar year beginning with the calendar year after the woman entered the DNFS until end of observation (a year in which she died or a year in which she outmigrated in the following year). Under this scheme, a woman first seen on March 1, 1975 has observations for 1976 until the year of her death or the year before she migrated out of the DSS area. Some migrants returned to this area; however, because we have no information on their fertility during the intervening period, only the first residence spell is included in this study.

Discrete-time hazards models are used to model the hazard of dying within a given person-year of observation. To take account of multiple observations on the same individual, each woman was treated as a cluster. The dependent variable is a dummy variable indicating whether an individual died during a given person-year. STATA was used for all analyses. We present the relative odds of dying related to each predictor in a model.

Definitions of variables

In our earlier analyses, the following variables were significantly related to mortality risks. They are included here as controls for early socioeconomic status and health:

age at the start of the person-year;

religion (Hindu or Muslim);

schooling (whether or not a woman had no formal schooling);

body mass index (BMI), measured at the start of followup; and

height (in cms. and, alternatively, as a set of dummy variables indicating quartile of height).

Of the 2444 DNFS women, 2003 had both their height and weight (and, therefore, BMI) measured and comprise the sample for this study. The followup period commences with the later of the first year after entry into the DNFS or the first year in which weight was measured. Height, as perhaps the best proxy for health status before reproduction commenced, is included to control for the endogeneity of health and reproduction. We were, however, concerned that women who were very young at the time their height was measured might not have achieved full growth. But the average height of adolescents aged 17-19 does not differ significantly from those who were older at measurement (results not shown). There are 57 women whose height was measured when they were under 17. All analyses were repeated including and excluding them; since results differed only slightly, they are included in all analyses reported here. Body Mass Index was calculated as weight/height, using the woman=s *reference* weight.[2]

There were 101 deaths observed in the 31,663 person-years under 55 contributed by the 2003 women. In addition, 566 women were observed after reaching age 55; an additional 34 deaths occurred during the 3,422 person-years they contributed at ages 55+. Women with and without height and BMI measures were compared on characteristics found earlier to affect survival chances (age, schooling, religion); there were no significant differences (results now shown).

We use three time-varying **fertility measures**, parity, DRAT, and recency of a birth. To test for nonlinear relationships to mortality, parity and DRAT are introduced alternatively as a single interval variable and as a set of dummy variables.

Parity at the start of a given person-year represents the number of times a woman was exposed to the risks associated with bearing a live-born child. Unfortunately, there are too few nulliparous women to permit separate examination of the effect of never having had a live birth. Instead, in the dummy variable formulation, the lowest category is 0-2. For the *older* sample, parity is time-invariant because no births occurred after age fifty-four.

Duration ratio (DRAT) is defined as the ratio of a woman=s parity at the start of a person-year to

[2] Most women had more than one weight measurement taken during the DNFS, some while pregnant. Therefore, a pregnancy-adjusted reference weight was estimated as follows: for women whose first weight measure was taken when they were neither pregnant nor in the first three months postpartum, that weight was used. For women whose first measure was during this period, the first measure after 3 months postpartum was used. For those who had no subsequent measure after 3 months postpartum, weight at 3 months postpartum was imputed using a regression model based on women whose weight was measured directly both during the relevant period and after the third postpartum month. Preliminary analyses showed significant seasonal variation in weight. Therefore, weight was also estimated taking into account both season and pregnancy status. Results with this weight measure did not differ from the pregnancy-adjusted reference weight, so are not reported in this paper.

Matlab 1979 age-specific fertility rates cumulated to her age (following Boulier and Rosenzweig 1978; Chowdhury et al. 1982). It serves both as an indicator of the pace of cumulative fertility and an indirect estimate of birth spacing. DRAT is introduced alternatively as an interval variable and as a set of dummy variables representing the quartiles of its sample distribution.

Recency of a live birth is introduced to examine the extent to which mortality is elevated in subsequent to a birth. It is represented by six dummy variables showing whether a birth occurred in the current person, the previous year, or in the second, third, fourth, or fifth years before the current person-year. Alternatively, we use two dummy variables representing whether there was a recent birth (in years 0-2 before the current year) or a less-recent birth (in years 3-5 before the current year).

Interactions between recency of a live birth and parity or DRAT are introduced to determine whether the effect of having an additional child differs by parity or pace of childbearing.

As mentioned above, data are lacking on a number of important reproductive variables, including whether a woman was pregnant in a given person-year, her gravidity, number of stillbirths/ miscarriages, age at first birth, age at menopause, age at menarche, induced abortions, and lactation behavior. In addition, we have no information on changes in marital status, which may influence both fertility and survival risks.

To distinguish the short-term effects of reproductive behavior and mortality from the long-term effects for elderly (i.e., postmenopausal) women, we consider two subsamples defined by age at the start of a given person-year in addition to the *total sample* of all person-years: the *younger subsample* includes women-years in which the starting age was under 55 (the oldest age at which a birth was recorded in this sample was 54; under 1% of the 3,617 live births occurring in the prospective period were to women over 50) and the *older subsample*, those person-years for which age at the start was at least 55.

RESULTS

Characteristics of each sample are shown in Table 1. Over three-quarters of all women had no education, and among women who reached 55 during the DNFS, 84% had no education. Nearly 13% of all women were Hindu, but only 9% in the older subsample. (Hindus were much more likely to migrate out of Matlab than Muslims, so that over the course of the followup period, the sample observed in a given year became progressively more Muslim). The women are on average quite short (148 cms.), with older women differing little from younger. In addition, they are quite slight, with average BMI only 18.5, again differing little in the two subsamples. At the start of followup, women averaged 30 years of age, had 4 children, and slightly faster pace of childbearing than characterized 1979, the year from which the standard pace was taken. At last observation, they averaged 47 years of age and 5.9 children. DRAT was slightly lower, 1.09, a consequence of the decline in the pace of fertility over the followup period. The percent with a recent birth at the start of observation was higher than the percent with a less recent birth, reflecting the selection of women of known fertility into the sample and recent marriage of some of the youngest women in the sample. The percent with recent and less recent births dropped quite dramatically from the first to last observation -- due in part to aging of the women and the overall decline in fertility in Matlab.

Factors related to survival when women are under 55 (the younger sample)

The baseline model (Model 1 in Table 2) includes as predictors of survival only age and early socioeconomic status (Hindu, no schooling). As expected, odds of dying increase with age. An age-squared term, included to test for curvilinearity, was not significant for the younger sample and is not included in Models 1-8. Odds are also 80% higher for Hindus compared to Muslims and 90% higher for those with no schooling compared with those who attended school. Height, entered linearly, was not significant; however, a non-linear relationship emerged. The shortest women (first quartile) experienced higher mortality risks than their taller peers. BMI, added next, improve model fit (Model 2); the higher BMI, the lower the risk of dying. But once body mass and height are taken into account, Hindus no longer appear to be at significantly higher risk. Because of the importance of religious differences in Bangladesh, we retain the religion variable in all subsequent analyses.

Neither parity nor the pace of childbearing appears to have any effect on the odds of dying. The results for parity and DRAT are shown as Models 3 and 4 in Table 2. When the dummy variable alternatives were used, in each case none of the individual variables was significant; nor was the set taken as a whole (results not shown). We also tested for interactions between parity or DRAT and age, socioeconomic status, and early health. Again, interactions were not significant, singly or as group. Thus, there appear to be no cumulative effects of either the number or pace of childbearing.

Risk of dying is, however, much greater in the period shortly after a live birth. We first introduced six dummy variables indicating whether a live birth occurred in the index person-year or each of the five previous years (Model 5, Table 3); none achieved statistical significance individually, but they did so as a group. The coefficients fell clearly into two groups of three. It is likely that too few births occur in any given year for the effect to reach statistical significance. In fact, in our earlier work, using the recognized incomplete data on cause of death, we were not able to detect increased risk due to maternal mortality (Duffy 2000). We therefore used the alternative formulation of two variables, the first representing occurrence of a birth in the current or previous 2 years and the second representing occurrence of a birth in years 3-5 before the current year (Models 6 and 7, Table 3). Women who gave birth recently had significantly higher mortality risks compared to women who had no recent live birth. We also tested and found that the mortality risks of women who had only one birth in that period were not significantly different from women who had two or more births (results not shown). Births that occurred in the more distant past had no significant effect on the mother=s survival. Again, there were no significant interactions between the fertility variables and age, socioeconomic status, or early health; nor was there an interaction between recency of a birth and parity or pace of childbearing. Finally, once recency of a birth was included in the model, we added parity and DRAT back in. In this case, women who were slow at bearing children (first quartile of DRAT) had higher risks. This is the final model for women when they are under 55 (Model 8, Table 2). We tested whether the effect of DRAT varied with time period because of the fertility decline. Our hypothesis was that as women increasingly deliberately controlled their fertility, those who were in the first quartile might not be at greater risk. No such effect was found (results not shown).

In summary, neither absolute nor relative parity is associated with significantly elevated mortality risks. But a live birth does carry with it higher mortality risks for the mother for a far longer period than the 42 days used to define maternal mortality. Women in rural Bangladesh appear to experience higher mortality during the year of a birth and for the subsequent 2 years - regardless of their achieved parity or rapidity of childbearing, or their age, early socioeconomic status and early health, although each of the non-fertility variables is independently associated with the risk of dying. Once recent births are taken into account, there is higher risk for women whose pace of childbearing was slow compared to their peers.

Factors related to survival when women were 55 and over

In this small sample, none of the variables we introduced were significant, with the exception of age itself (results not shown). None of the socioeconomic, health, or fertility variables nor their interactions were significant. We note that the odds ratios of the schooling variable is quite large (5.8), but still not significant. In addition, there is some suggestion that women who had a birth after age 40 had lower risks, but the effect is not significant. (The majority of women had a live birth after the age of 35 although the percentage that gave birth after age 40 and after age 45 declined dramatically, as expected.) Such a result would be difficult to interpret, since those who were in better health at age 40 or age 45 might selectively be those who both lived longer and were able to have a subsequent live birth.

Factors related to survival in the total sample

The final model in Table 2 is based on Model 8 for person-years under age 55, the addition of person-years at 55+, an age-squared term, and interactions of all other variables with a dummy variable representing whether age in the person-year was <55 or 55+. When older ages are included, the relationship to age becomes curvilinear, as indicated by the significant age-squared term. All other factors remain significant with two caveats: women who were short and whose pace of childbearing was slow were at increased risk of dying only at ages under 55. In addition, at older ages, women who had high parity or faster pace of childbearing were at no different risk than others their age.

DISCUSSION AND CONCLUSIONS

This study adds new evidence to the debate over the effects of women=s reproductive careers on their own survival. Much of the early literature claimed that fertility, especially repeated rapid childbearing under poor conditions, was deleterious to the health and survival of women. They would suffer from maternal depletion and other ills that would lead to poor health and early death. We would describe these hypotheses as representing a >cumulation= theory relating a woman=s fertility to her mortality. This claim provided at least part of the basis for promotion of family planning programs. Another of the well-known claims is that, since children are the usual source of support in old age in much of the world, fertility effects would go in the opposite direction for older women -- the more children the better for an older woman.

This study addresses both of these hypotheses. For rural Bangladeshi women of childbearing age, it appears quite conclusive that their survival is NOT directly related to either the number of children they have born in the past nor to the speed with which those children were produced. Taken together, the negative results regarding parity and DRAT suggest that higher fertility is not correlated with serious health risks due either to maternal depletion or to other mediating factors. In other words, we find no evidence of a cumulative effect of childbearing on a woman=s survival.

Rather, our evidence strongly suggests that the risks women face have to do with each birth, taken alone. The well-known maternal mortality risk is not the only one women in rural Bangladesh face: rather, they appear to have elevated mortality risks for several years, not just in the immediate perinatal period. The elevation in mortality risks found in the three years following a live birth may be due in part to problems related to the pregnancy or birth itself, in part to depletion in the period after the birth, and in part to long-term illnesses that either develop during pregnancy and childbirth or that are exacerbated by pregnancy and childbirth such as anemia, diabetes or cardiovascular problems. But we emphasize that these risks are unrelated to parity *per se* or to parity relative to Matlab fertility rates (there was not significant interaction between having a recent birth and DRAT). Therefore, there does not appear to be elevated risk due to maternal depletion. In fact, it is those with the *slowest* childbearing that have higher risks, which may well be because the same factors caused them to both have low fertility and high mortality risks. The shortest women and/or those with low body mass would be expected to be at greatest risk of maternal depletion and, therefore, to have higher risks associated with a recent birth compared to women who were healthier. We find no difference in the effect of a recent birth by height or BMI.

These findings do not negate the effects of number of children on mothers= survival. Rather, what they say is that *each time a woman has a child*, she faces an increased risk of dying in the relatively short period (*2*-3 years) after that birth. Thus, a woman who plans to have seven children has seven chances of succumbing to this risk, whereas the woman who plans two children has only two chances. Reducing fertility, therefore, does reduce the chances that women die from maternity-related causes. But were there to be two women who were twins and alike in all ways except their fertility and both had a child four years ago, this study suggests that the twin who survived three years after the birth of her seventh child and the twin who survived three years after the birth of her second child have the same age-specific mortality risks. The one exception to this finding is that, controlling for recent birth, the women whose childbearing pace is slowest are at increased risk during their childbearing years.

Many countries are currently involved in programs designed to reduce maternal mortality. Our results suggest is that women are at higher risk beyond the perinatal period and that research is needed to determine the causes of longer-term effects of a birth that lead to those later deaths.

Turning to older women, it is clear that this study cannot answer all questions of the later effects of reproduction. Older women in our sample do not demonstrate any long-term effects, negative or positive, of their reproductive experience. Possibly the follow-up period of twenty years is too short to detect long-term effects of childbearing on health, but this explanation seems unlikely. It is much more likely that the sample is too small to detect long-term effects.

The relationship between age at last birth and survival (not shown), which nearly achieved statistical significance, deserves some comment, primarily because it is not likely to be a fruitful area for research. We believe that such a relationship most likely is based on a common relationship to early health and socioeconomic status and possibly to adult socioeconomic status rather than a birth being causally related to increased longevity. It may be related to delayed menopause, itself a measure of better health (Doblhammer and Vaupel 1997). It is well-known that widows are at a substantially greater risk of dying compared to currently married women (Rahman, Foster, and Menken 1992; Rahman 1993). Since women who were widowed during their reproductive years are unlikely to have another birth, the survival disadvantage witnessed among women who did not give birth later in life and those who had slow childbearing earlier in life may very well be the result of being widowed. Unfortunately, we were not able to carry out the extensive analyses that would have been necessary to determine whether and when women were widowed.

There may be other weaknesses to this study. For one, the effect of family and social networks on mortality risks could not be assessed. There were also not enough nulliparous women in this sample to measure any threshold effects that having at least one child might have on mortality risks. In addition, age at first birth, which may be an important confounding variable, could not be assessed well in the data currently available. The DNFS data did record age at first birth, but we found these data to be of questionable accuracy. We plan to try to match the records of DNFS women in the Demographic Surveillance System prior to their entry into the study, but the task will not be simple because record-keeping procedures changed about the time of the 1974 census. It is also possible that the controls for both health and socioeconomic status are not adequate and that there may be an important confounding effect between health and/or socioeconomic status and mortality that is not accounted for with the available data.

This study was made possible only by the existence of reliable longitudinal data over an extended period of time. It points to the benefits of the investment that has been made over many years by ICDDR,B, its associates, and the agencies that have provided its funding.

Finally, we note that 73.4% of the original 2441 women in the DNFS participated in the Matlab Health and Socioeconomic Survey in 1996/97. They constitute 79% of all participants for whom a death record was not found in the DSS. The health of these surviving adult women is also strongly related over time to their early life conditions, including their early adult nutritional status (Duffy 2000, Menken and Duffy 2001). Of great concern, probably greater than the cumulative effect of fertility, is the continuing weight loss adult women experience. Close to half the DNFS women who survived until 1996 and participated in the Matlab Health and Socioeconomic Survey had lost 5% or more of their BMI over the intervening two decades.

In the future, as Matlab and the rest of Bangladesh goes through the epidemiologic transition, it is possible that there may be important long-term effects of reproduction on mortality among women. However, it appears, at this point, that the greatest risks associated with reproduction in Matlab occur in the short-term B and that the risk continues for several years beyond the immediate period that is usually considered in detecting maternal mortality. Data exist for Matlab that would permit examination of women=s mortality in the period subsequent to a birth for a much larger sample of women. Although no information on height and weight would be available for this larger sample, the public health and programmatic implications of the findings presented here make a strong case for carrying out this type of study.

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Table 1. Characteristics of DNFS women whose BMI was measured: *younger subsample (<55 in person-year), older subsample (55+ in person year*) and *total sample*.

		Younger subsample	**Older subsample**	**Total sample**
Number of **women**		2003	540	2003
Number of **person-years**		31663	3422	35085
Number of **deaths**		101	34	135
Characteristics of women				
Percent: **no schooling***		77.3%	83.6%.	77.3%
Percent: **Hindu***		12.7%	8.5%	12.7%
Mean and (sd): **BMI**@		18.5 (1.8)	18.2 (1.8)	18.5 (1.8)
Mean and (sd): **height** (cm)*		147.8 (5.2)	147.5 (5.4)	147.8 (5.2)
Characteristics of person-years (py)				
Mean and (sd) **age:** start of	First py observed	30.3 (8.9)	55 (0)	30.3 (8.9)
	Last py observed	45.1 (9.4)	60.4 (4.0)	46.8 (11.4)
	All py observed	38.0 (9.2)	58.9 (3.4)	40.1 (10.8)
Mean and (sd) **parity**: start of	First py observed	4.1 (3.1)	7.3 (2.4)	4.1 (3.1)
	Last py observed	5.9 (2.8)	7.3 (2.4)	5.9 (2.8)
	All py observed	5.5 (2.8)	8.1 (2.4)	5.7 (2.9)
Mean and (sd) **DRAT**: start of	First py observed	1.15 (.72)	1.35 (.41)	1.15 (.72)
	Last py observed	1.09 (.47)	1.35 (.41)	1.09 (.47)
	All py observed	1.13 (.49)	1.37 (.42)	1.15 (.49)
Percent **recent birth**: start of (0-2 years before current year)	First py observed	73.8%	0.6%	73.8%
	Last py observed	13.9%	0%	13.7%
	All py observed	32.0%	0.1%	28.9%
Percent **less recent birth**: start of (3-5 years before current year)	First py observed	59.2%	0.4%	59.2%
	Last py observed	16.4%	0.2%	16.2%
	All py observed	41.3%	0.3%	37.3%

* Measured at entry into Determinants of Natural Fertility Study
@ Estimated for year before start of followup period

Table 2. Relative odds of dying in a person year (p values in parentheses): Person-years for women whose BMI was measured, *Younger subsample* (person-years<55) and *Total sample*

	Model 1 Age + Early SES	Model 2 M1 + Early Health	Model 3 M2 + Parity	Model 4 M2 + DRAT	Model 8 M2 + recent birth + slow fertility	**Final Model** **Total sample** Model 8 + age interactions
Age at start of year	1.033 (.006)	1.029 (.016)	1.035 (.017)	1.030 (.013)	1.059 (.000)	0.973 (.553)
(Age at start of year)^2						1.001 (.028)
Hindu	1.789 (.025)	1.504 (.0126)	1.492 (.133)	1.494 (.132)	1.495 (.130)	1.470 (.103)
No schooling	1.895 (.040)	1.881 (.042)	1.894 (.040)	1.891 (.040)	1.855 (.047)	2.193 (.008)
Short (1st quartile of height)		1.551 (.033)	1.559 (.033)	1.559 (.033)	1.561 (.031)	
Short & age at start of year <55						1.472 (.050)
BMI		0.827 (.002)	0.829 (.002)	0.828 (.002)	0.823 (.001)	.837 (.000)
Parity			0.967 (.474)			
DRAT				0.861 (.480)		
Recent birth					2.432 (.000)	2.494 (.000)
Slow fertility (1st quartile of DRAT)					1.593 (.048)	
Slow fertility & age at start of year <55						1.611 (0.042)
-2 Log Likelihood Chi-Square	17.38	35.73	36.29	35.86	57.46	89.49
DF	3	5	6	6	7	8
Pseudo R^2	.015	.026	.026	.026	.036	.049

Table 3. Relative odds of dying in a person year (p values in parentheses): Person-years in DNFS followup period with age at start of year <55 (Younger sample) for women whose BMI was measured, models introducing recent births

	Model 5 M2(T2) + Births in recent years	Model 6 M2(T2) + Recent and Less Recent Births	Model 7 M2(T2) + Recent Birth
Age at start of year	1.045 (.002)	1.049 (.001)	1.051 (.000)
Hindu	1.503 (.126)	1.514 (.118)	1.517 (.117)
No schooling	1.856 (.046)	1.839 (.050)	1.829 (.051)
Short (1st quartile of height)	1.564 (.031)	1.564 (.031)	1.565 (.030)
BMI	0.823 (.049)	0.821 (.001)	0.820 (.001)
Birth in current person year	1.877 (.081)		
Birth in current person year - 1	2.016 (.041)		
Birth in current person year - 2	1.818 (.060)		
Birth in current person year - 3	0.710 (.375)		
Birth in current person year - 4	0.828 (.571)		
Birth in current person year - 5	0.949 (.867)		
Recent birth (current + previous 2 years)		2.249 (.002)	2.197 (.001)
Less recent birth (3-5 previous years)		.885 (.637)	
-2 Log Likelihood Chi-Square	53.86	55.93	55.35
DF	11	7	6
Pseudo R^2	.033	.033	.033