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Heterogeneous Effects of Birth Spacing on Neonatal Mortality Risks in Bangladesh

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ABSTRACT

The negative relationship between birth interval length and neonatal mortality risks is well-documented, but the possibility of heterogeneity in this relationship has been largely ignored. Understanding variation in the strength of this relationship may be important for adjusting family planning programs strategies for issues regarding fertility regulation and maternal and child health, however, as donor support of these programs has been declining in recent decades (Cleland et al., 2006). Using the Bangladesh Maternal Mortality and Health Care Survey 2010, this study investigates how the effect of birth interval length on neonatal mortality risks varies along three dimensions: birth cohort, maternal age at birth, and maternal education. The results show that the average effect of interval length on mortality has approached zero across birth cohorts, but that significant variation exists with respect to maternal age and education. Young women and those with little education, both of which make up a large share of the Bangladeshi population, can disproportionately benefit from increasing spacing between births. These results were based on within-family models and therefore not a product of unobservable heterogeneity across mothers. They also suggest that specifically targeting these groups may lead to significant improvements in overall neonatal mortality rates, but there are some significant challenges in reaching these women.

Keywords: Birth Spacing, Neonatal Mortality, Bangladesh, BMMS 2010

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INTRODUCTION

A consistent negative relationship between birth interval length and infant mortality risks has been identified in a wide variety of contexts (Boerma & Bicego, 1992; Cleland & Sathar, 1984; Curtis, Diamond, & McDonald, 1993; Hobcraft, McDonald, & Rutstein, 1985; Kozuki & Walker, 2013; Mahande & Obure, 2016; Millman & Cooksey, 1987; Molitoris, 2017; Palloni & Millman, 1986; Pebley, Hermalin, & Knodel, 1991; Rutstein, 2005). The ubiquity of this relationship has led the World Health Organization to recommend that mothers in developing countries space their births at least three years apart (WHO, 2007), which has been implemented in community-based family planning programs (Ahmed et al., 2015). Despite widespread agreement regarding the importance of birth spacing for improving both maternal and child health outcomes, there has been little research into the heterogeneity of this relationship. There is an emerging picture of variation in the effect of birth intervals across populations. It has been shown, for example, that the duration of birth intervals generally only reduces infant mortality risks in populations in which mortality is high (Millman & Cooksey, 1987; Palloni & Millman, 1986), while in low-mortality settings there seems to be little to no consequence of birth spacing for infant health (Ball, Pereira, Jacoby, de Klerk, & Stanley, 2014; Mignini et al., 2016). A recent study using historical data even showed that as the overall level of child mortality declined, the negative effect of preceding inter-birth interval length on mortality approached zero (Molitoris, 2017). This is perhaps unsurprising as many of the theoretical mechanisms linking birth intervals to child health outcomes operate either through nutritional deficiencies or the transmission of infectious diseases, both of which will be less common in a low-mortality context (Conde-Agudelo, Rosas-Bermudez, Castaño, & Norton, 2012).

There has been little research, however, regarding heterogeneity in the relationship between interval length and mortality risks within populations. That is, do longer birth intervals disproportionately affect the chances of survival for some children over others depending on, for example, their socioeconomic circumstances or mothers’ characteristics? It is important to identify the existence of heterogeneous effects, as it can assist family planning programs to more effectively target subpopulations that can benefit the greatest from controlling their tempo of fertility. More precise targeting may be increasingly necessary for realizing improvements in maternal and infant health as international donations to family planning programs have continued to decline in recent decades (Cleland et al., 2006), and major donors, like the United States government, have sought to
impose stricter requirements on NGOs relying heavily on its foreign aid (Crane & Dusenberry, 2004).

The aim of this paper is to examine heterogeneity in the relationship between birth interval length and neonatal mortality risks in Bangladesh using the 2010 Bangladesh Maternal Mortality and Health Care Survey 2010 (BMMS 2010). The advantage of using the BMMS over other surveys of Bangladesh, such as the BDHS, is that it has a much larger sample size (over 175,000 households), making it possible to rigorously investigate heterogeneity in population processes without losing much statistical power. In family planning circles, Bangladesh is a well-known success story, having witnessed sustained fertility decline to near-replacement levels and increased contraceptive uptake within a context that, until recently, had seen little economic development and continues to maintain traditional norms governing gender-roles and sexual behavior. Despite enormous progress, recent DHS estimates suggest that fertility has plateaued just above replacement-level and that intentions to use contraception are declining. Furthermore, the mean age at first birth continues to be extremely low by international standards, at about 18.5 years old. Unlike fertility, the under-five mortality rate has continued its remarkable fall, but it is still substantial at about 46 per 1,000 population and varies widely along socioeconomic lines (National Institute of Population Research and Training (NIPORT), Mitra and Associates, & ICF International, 2016).

The present study contributes to the current body of literature by demonstrating that the strength of the relationship between birth interval length and neonatal mortality risks varies along several dimensions, a fact which has thus far been largely ignored and which can offer valuable insight for family planning programs. First, it will describe how this relationship has evolved across birth cohorts, as previous research would lead one to suspect that it is becoming weaker as overall mortality subsides. Second, it will examine whether or not the relationship disproportionately affects women of certain ages. Of particular interest is how the survival prospects of children born to young women are influenced, as Bangladeshi women often begin childbearing at young ages in which they also tend to have substantially shorter birth intervals and are at higher risk of pregnancy-related complications. Finally, differences in the relationship between birth intervals and maternal education will be investigated as there is evidence suggesting that these women are at a heightened risk of experiencing shorter birth intervals and also tend to have disproportionately high rates of child mortality (de Jonge et al., 2014).
HETEROGENEITY IN FERTILITY AND CONTRACEPTIVE USE IN BANGLADESH

Before turning to the analysis, it is necessary to highlight some important features of Bangladesh’s demographic regime as these will be of central importance for discussing heterogeneity in the effect of birth spacing on infant mortality risks. Unless otherwise noted, the patterns and trends highlighted below come from the 2014 DHS Report for Bangladesh (National Institute of Population Research and Training (NIPORT) et al., 2016). In the past four decades Bangladesh’s total fertility rate (TFR) decreased from over six births per woman to 2.3, where it seems to have leveled-off. The decline has occurred among women of all ages, though it was primarily women above age 40 whose fertility decreased the most. Since the beginning of the DHS program in Bangladesh in 1993, the smallest relative decrease in age-specific fertility rates (ASFR) was actually among women aged 15-19. Compared to populations with similar TFRs, the ASFR for women in this age-group is very high at 113 births per 1,000 women.

It has not just been the quantum of fertility which has changed, but also its tempo. The median age at first birth for women aged 20-49 has slowly been increasing over time, but it remains quite low at around 18.5 years old. Median inter-birth intervals have always been quite long in Bangladesh partly due to norms promoting prolonged and nearly universal breastfeeding (UNICEF, 2016); the mean duration of breastfeeding is over 30 months, although exclusive breastfeeding is typically terminated well within six months (Akter & Rahman, 2010; Giashuddin & Kabir, 2004). Perhaps unsurprisingly, both the median age at first birth and the length of median birth intervals are positively correlated with household wealth and women’s education. Even when the TFR was above six births per woman, the median interval was 33 months (Cleland, Phillips, Amin, & Kamal, 1994). By 2014, this had increased to 52 months. But the latter figure obscures wide variation in birth spacing, particularly across age groups.

Nearly half of second and higher parity births to teenage women occur within less than two years of the preceding birth, while for older age groups only between 5-10% of intervals are so short. It is not surprising that intervals will tend to be shorter in younger age groups, as there is naturally a loss of fecundity as women age and, in the present context, women tend to start and end their reproduction at younger ages, meaning that a larger share of births to older women will be unintentional and more likely to occur after longer intervals. Furthermore, there also is a lower contraceptive prevalence among young women for a variety of reasons. However, given that these
statistics come from cross-sectional surveys, the large share of short intervals among younger women is also partially a matter of selection. That is, most married women’s exposure to pregnancy in the age range 15-19 will generally be left truncated as they will tend to marry at some point in that age range. Therefore, in order to have had a second or higher order birth before turning 20 years old, it practically must have occurred within two years of the first birth. This would suggest that young women having multiple births in their teenage years may be different than those who do not. This is an issue that will be addressed later in the empirical analysis.

The substantial decline in fertility was strongly related to the increase in the use of contraception, particularly modern methods (Bongaarts, 2014). Contraceptive uptake has been significant in Bangladesh, rising from about 8% in 1975 to over 60% by 2014. The period not only saw a large increase in the adoption of contraception but also a dramatic change in the method-mix used by married women. Since the first Bangladesh Fertility Survey in 1975, the share of currently-using women relying on traditional methods has declined from over one-third to 12%. Early on in the history of family planning in Bangladesh, it was women in their thirties and forties who adopted contraception en masse, and permanent sterilization was the dominant form of modern contraception promoted by family planning programs until the late-1980s (Schuler, Hashemi, & Jenkins, 1995). Recent decades have seen rapid growth in the use of contraception among younger women, particularly between the ages of 15 and 24, and during that period oral contraceptives and injectables have become the most widely used modern methods. Nevertheless, the use of contraception in these younger age groups remains low for reasons that will be discussed below.

The high rates of teenage childbearing in Bangladesh are largely due to two factors: a longstanding tradition of early marriage and a low rate of contraceptive use among currently-married teenage women. Nearly half of all women are married before age 20, often to significantly older men; the difference in male and female mean age at first marriage was six years in 2014 (Bangladesh Bureau of Statistics, 2015). Furthermore, a large share of marriages occur before the legal age of consent, which is 18 years old. Less educated women are also more likely to get married at younger ages.

Compared to women at other ages, married women below age 20 have a much higher unmet need for contraception. In particular, the unmet need for spacing is especially high for young women, while the unmet need for limiting family size is the lowest for this age group. Among all currently-married women, those aged 15-19 are the least likely to be currently using any form of contraception, regardless of whether one considers traditional or modern methods. This pattern is
due to a combination of factors. These include a lower rate of cohabitation in couples with young brides, high discontinuation rates among those who do practice contraception, and greater gender inequality in individual and household decision-making for younger women.

It is not unusual for young brides to live apart from their husbands and this may have a natural effect of reducing exposure to pregnancy by limiting sexual contact between spouses, which may consequently lower the demand for contraception or lead to irregular (and less effective) use. Among younger women who do use contraception, oral and injectable contraceptives are the most popular choices, but discontinuation rates for both of these are among the highest of all available methods. Apart from intentions to conceive or a loss of fecundability, of which the former is common among young women, major reasons for high discontinuation rates are related to either the presence of side effects or health concerns. A qualitative study of women’s perceptions of contraception in Bangladesh revealed that modern contraceptives, particularly hormonal methods, are perceived as having the potential to cause permanent damage to a woman’s reproductive organs and as disruptive to the body’s natural functioning (Salway & Nurani, 1998).

Married teenage women also have less influence on both individual and household decisions compared to older women. In fact, many of these women seem to have had limited freedom even in the choice to get married in the first place. Among women marrying before reaching the legal age, it appears that nearly 60% would have preferred to marry later. Within marriage the story is much the same. Even concerning a woman’s own health care, women below age 20 are less likely to report having the freedom to make decisions on such matters without their husbands’ input. These kinds of limitations on women’s freedom have often been linked to the system of purdah – institutions that push women into social, economic, and physical seclusion (Amin, 1997). It is not unreasonable to suspect that part of this imbalance in power is based on well-meaning intentions. That is, significantly older husbands, who may be more familiar with issues surrounding health care, may insist on advising their young wives on such matters, of which a teenager may be unfamiliar. Be that as it may, this lack of autonomy will also effectively limit young women’s possibility of adopting contraceptives from health facilities and contribute to a higher unmet need for contraception. This is clear from the fact that women who report participating in fewer major household decisions are less likely to use any contraceptive method, especially modern methods, and tend to have a greater unmet need for spacing children. Furthermore, recent work has shown that Bangladeshi women who discussed family planning with their husbands were more likely to use contraceptives (S. M. M. Kamal & Islam, 2010). It is
unclear, however, if this is because their husbands are more supportive of their choices or are merely ambivalent, thereby retaining the power to place blame on wives for negative consequences of their choices (Schuler et al., 1995).

It does not appear that women’s educational attainment is related to their involvement in family decisions, but there are clearly different expectations of a woman’s role in a relationship across different levels of education, and this may have implications for their choices regarding contraception. Less educated women are more likely to view their husbands as dominant figures in a relationship. For instance, one-third of women with no education believe that their husbands are justified in administering corporal punishment if they displease him in various ways; among highly educated women, this figure is 16%. Women who are more likely to justify corporal punishment are also more likely bear the onus of contraception in a relationship. These women tend to rely more on temporary modern female contraceptives and their husbands are less likely to use male contraceptives. Furthermore, less educated women tend to rely on traditional methods to a greater extent.

**HETEROGENEOUS EFFECTS OF CAUSAL MECHANISMS**

The three most commonly explored mechanisms linking birth interval length and neonatal mortality have to do with maternal depletion, sibling competition, and the transmission of infectious disease. These have been covered in detail elsewhere (Conde-Agudelo et al., 2012), but a brief description of these will highlight why interval length may be expected to affect children’s outcomes to varying degrees depending on other characteristics.

The maternal depletion hypothesis argues that short intervals do not allow women to fully recover their nutritional stores from a prior birth, which may lead to diminished fetal growth as their bodies compete with that of the fetus for nourishment (Gibbs, Wendt, Peters, & Hogue, 2012; Winkvist, Rasmussen, & Habicht, 1992). The sibling competition hypothesis claims that closely spaced siblings will compete for similar resources from their parents, which diminish their parents’ per capita investments, such as the quality or quantity of calories they can consume or a certain level of cleanliness in the home environment. Competition of this nature may lead to a weaker immune system for index children thereby placing them at greater risk of death from infection and, ultimately, death. The disease transmission hypothesis argues that closely spaced siblings will be
more likely to pass infections to one another and, because a younger child will generally have a less-developed immune system than its older sibling, it will be more likely to die at a young age.

It is not the intention of the present analysis to discriminate between these causal mechanisms, but they should nevertheless be useful for predicting variation across subpopulations in the strength of the effect of birth intervals on neonatal mortality risks. Given these mechanisms, I will briefly discuss how one could expect heterogeneity in the effect of birth intervals on mortality risks to appear along the three dimensions of interest: birth cohort, maternal age, and maternal education.

Previous research has shown that birth interval length has a weaker influence on infant child mortality when the overall level of mortality is lower (Ball et al., 2014; Mignini et al., 2016; Millman & Cooksey, 1987; Molitoris, 2017; Palloni & Millman, 1986). Why exactly this is the case is yet to be understood, but it is most likely related to at least one of two trends that typically accompanies mortality decline. The first relates to population-wide improvements in nutrition. If the quality or quantity of calories in a population improves, the importance of interval length as a determinant of mortality should diminish as the nutrient-depleting effects of short intervals will be offset by general gains maternal and infant nutrition. That is, improved nutritional status will operate via the maternal depletion and/or the sibling competition mechanism. The second relates to the epidemiological environment. Populations with high levels of mortality generally have a high prevalence of infectious diseases. As the epidemiological transition progresses, these become less of a threat, especially to children, and short intervals become disassociated with a greater threat of transmission between siblings. Disentangling the importance of these two trends may very well be impossible as improvements in nutrition will also improve host resistance, but the prediction we can derive remains the same. Bangladesh has seen a remarkable decline in mortality in the last two decades, going from under-5 mortality rates of 133 per 1,000 in 1993 to only 46 per 1,000 by 2014. This leads to the expectation that mortality risks of children born to later cohorts should be less influenced by birth interval length than those born in earlier years.

Of the three abovementioned mechanisms, one should expect maternal age to be directly linked only to the maternal depletion hypothesis. That is, there is no inherent reason to expect a mother’s age to be connected to sibling competition or infection transmission other than through socioeconomic factors. Young mothers, particularly those conceiving close to menarche, tend to have several high-risk characteristics not found in older mothers due to biological or gynecological immaturity (King, 2003). These include limited amino acid production in the third trimester
(Thame, Fletcher, Baker, & Jahoor, 2010), under-developed reproductive organs, and higher risks of conditions associated with neonatal mortality, such as pre-eclampsia and anemia (Duley, 2009; Scholl, Hediger, & Belsky, 1994). Under the maternal depletion mechanism, one would therefore expect longer intervals to be more beneficial to young women, particularly teenage women, as longer intervals may allow them to both recover and mature.

With regard to socioeconomic background, there is no sure way to differentiate between these three mechanisms, as they would all operate through either differential exposure to nutritional deficiencies or to disease. One would nonetheless expect that these factors would be disproportionately unfavorable for women in worse socioeconomic conditions. Previous research has shown clear nutritional differences across educational groups in Bangladesh; maternal education is strongly inversely related to the risk of both childhood stunting and maternal underweight (Campbell et al., 2010; Rahman & Chowdhury, 2007; Semba et al., 2008). Furthermore, there are large differences across educational groups in terms of children’s vaccination coverage (National Institute of Population Research and Training (NIPORT) et al., 2016). Regardless of which mechanism is operating, one would expect that the marginal benefit of increasing birth intervals would be greater for low SES women than for high SES women. Longer intervals would allow women in a lower socioeconomic position to recover fully from the preceding birth, provide better nutrition for their children, and also limit their children’s exposure to higher risks of infection from siblings. There is thus ample reason to expect that the relationship between birth intervals and neonatal mortality would be disproportionately strong for women of low socioeconomic standing.

DATA

The data used in this study come from the cross-sectional Bangladesh Maternal Mortality and Health Care Survey 2010 (BMMS 2010), a nationally representative sample of about 175,000 households, which includes 180,000 ever-married women between the ages of 13 and 49. This is a substantially larger sample size than that found in, for example, the Bangladesh Demographic and Health Surveys, the latest of which had a sample size of 18,000 ever-married women in 2014. The large sample in the BMMS 2010 was deemed necessary in order to accurately identify real changes in maternal mortality, which are rare events. The data included information on a wide variety of topics relating to maternal health care utilization, demographic characteristics, socioeconomic
conditions, and fertility. Although maternal mortality was the survey’s main focus, it also included basic demographic information about all of the women’s children. In total, this survey provides information about some 470,000 children born to the women in the sample and it is these children who are the main unit of analysis.

The sample used in this study was restricted to only include non-firstborn children to women who had at least three births. This restriction was imposed because the analysis will make use of a within-family design that will account for unobserved heterogeneity between mothers. The omission of firstborns is due to the fact that the main independent variable of interest is the length of the preceding inter-birth interval, which is naturally undefined for the first birth. The sample was also restricted to women aged 30 or higher at the time of the survey in order to avoid including women who were unusually highly parous at young ages. Children born following intervals of less than six months were also excluded, as it was unclear if these intervals were real or errors in the data. In addition, those born following intervals longer than ten years were also excluded, as intervals longer than this are extremely rare and are likely skew results. Only about 1.8% of all higher order births were excluded from the analysis due to an anomalous interval length. Of the excluded births, the large majority (94%) were births occurring after a period of more than ten years. Children born either prior to 1975 or after 2009 were also excluded. Just a handful of children had birthdates occurring before 1975. Children born after 2009 were excluded because the collection of the data took place in 2010 and some children’s exposure to neonatal mortality was truncated for that year. This led to an analysis sample size of over 235,000 children born to about 68,000 women. The ever-married cohorts born in 1980 or older had given birth, on average, to at least three children, so the restrictions put in place regarding family size do not restrict the sample to an unusual group of women as would be the case if this restriction were imposed on younger cohorts who tend to have preferences for smaller families.

**METHODS**

The relationship between preceding birth interval length and neonatal mortality is estimated using linear probability models with maternal fixed-effects (FE), such that:

\[ Y_{ij} = S_{ij} \beta_1 + X_{ij} \beta_{k,ij} + \theta_j + \varepsilon_{ij} \]  

(1)

The outcome variable, \( Y_{ij} \), is a binary variable taking the value of 1 if the child died within the first 28 days of life and 0 otherwise. The main independent variable, \( S_{ij} \), is a continuous variable
measuring the inter-birth interval in years between the index child’s birth at parity $n$ and that of their older adjacent sibling born at parity $n-1$. The birth interval was assigned a cubic functional form in order to account for the well-documented non-linear relationship between birth interval length and neonatal mortality risks (Hobcraft et al., 1985; Rutstein, 2005). This approach is preferable to treating the variable as a stepwise categorical variable, which would require including a large number of parameters and run the risk of overfitting the relationship between the variables of interest. $X$ is a vector of individual-specific control variables, including the mother’s age at birth, the child’s birth year, the birth order of the child, multiplicity of birth, sex of the child, and number of siblings alive at the time of birth. Mother’s age at birth and the child’s birth year were included as cubic functions in order to account for the non-linear relationship between neonatal mortality risks and maternal age (both older and younger mothers tend to have higher risks of neonatal mortality) as well over time as mortality has declined in Bangladesh. The descriptive statistics for the model’s covariates may be found in table 1.

| TABLE 1 HERE |

The models use the within-estimator to control for unobserved heterogeneity across mothers which may simultaneously influence both the interval length of a child and their probability of dying. For this reason the error term is divided into a family-specific component, $\theta_j$, and an individual-specific component, $\varepsilon_{ij}$. This is a necessary adjustment as women who tend to have shorter intervals may also tend to have disproportionately higher risks of child mortality for unobserved reasons. For example, women who do not breastfeed at all, breastfeed for shorter durations, or only do so in combination with other feeding practices may be at a greater risk of conceiving a child shortly after birth and their children may be at a greater risk of dying from diarrheal diseases. Recent work has argued that taking unobservable heterogeneity into account is necessary to avoid producing biased estimates of the relationship between birth intervals and mortality risks of children at different ages (Ball et al., 2014; DaVanzo, Hale, Razzaque, & Rahman, 2008; Molitoris, 2017; Zenger, 1993). The models therefore refer to variation within mothers, thereby eliminating the possibility that estimates are being driven by compositional differences between short and long spacers. For comparison, results from the same models without maternal fixed-effects will also be presented.

The basic model is then extended by including interaction terms to examine how the relationship between the length of inter-birth intervals varied by the child’s birth year and the mother’s age at birth. It was not possible to investigate heterogeneity in this relationship across
educational groups with interaction terms, as maternal education does not vary across children and, therefore, cannot be estimated in the within-family design. Instead, the models were then stratified by mothers’ educational attainment. That is, four separate models were estimated for each educational category available in the survey. These were: no education, some primary, completed primary, and some/completed secondary or higher. Based on the abovementioned models, marginal effects of birth interval length were then estimated across different values of the interacted variable, while holding all other variables in the model at their means. This allows us to investigate the effect of “adding” an additional year to an average birth interval on the risk of neonatal mortality at different ages at birth, in different birth years, and across various levels of education. In the absence of heterogeneity in this effect, we would expect that marginal effects of birth interval length should be equal regardless of maternal age or education. If some groups benefit more greatly from longer intervals than others, we would expect a larger negative effect of increasing birth interval length on the probability of a child dying for some groups over others.

RESULTS

Variation across Birth Cohorts

FIGURE 1 HERE

The strength of the relationship between interval length and neonatal mortality risks has been changing across birth cohorts (figure 1). In both panels, we can see that the marginal effect has been approaching zero in a more or less linear fashion. For children born in the 1980s, there was a stronger impact of a longer birth interval on survival than for those born in the 2000s. The magnitude of this effect, however, was heavily influenced by unobservable maternal characteristics. When we compare the OLS estimates, which do not account for unobserved compositional differences between mothers, with the maternal FE estimates, we see that the change has been less dramatic, but still substantial. For the 1980 cohort, for instance, the predictions based on the OLS estimates suggested that a one year increase in birth interval length was associated with a reduction in the probability of neonatal death by more than 0.02, whereas that based on the FE estimate was about half that at just below 0.01. Nevertheless, there has been a real shift over time. The OLS predictions suggested that the marginal effect of interval length is approaching zero, while the FE predictions suggest it has already overlapped with zero. In other words, on average, there is no longer a relationship between neonatal mortality risks and birth interval length, once unobservable
maternal characteristics are controlled for. These are only average effects for birth cohorts, however, which mask underlying heterogeneity in the mortality response.

**Variation across Maternal Age**

When examining the heterogeneous effects of interval length with respect to maternal age at birth, it is clear that longer birth intervals benefit mothers of certain ages over others (Figure 2). The marginal effects of interval length on mortality risks were only calculated for mother’s giving birth between ages 15 and 35. Older ages were excluded due to a low number of births at these ages. In both the OLS and FE models, there was a nonlinear relationship between the effect of interval length on neonatal mortality by maternal age. Increasing the length of the preceding birth interval for children born to young mothers, particularly those below age 25, would have a greater mortality reducing effect than at older ages. This is a significant finding, as these are ages in which the majority of Bangladeshi women have already progressed to higher order births. In both the OLS and FE models, the marginal effect of increasing birth intervals was large for teenage women. The FE predictions suggest that a one year increase in interval length could reduce neonatal mortality risks by about 0.015, compared to about 0.025 in the OLS models. Above the mid-twenties, the effect of increasing interval length was more or less unchanged, but remained negative, implying that there is also a benefit for children whose mothers gave birth at later ages. To put these figures in perspective, the marginal effect estimated from the FE models is equivalent to about a 20% reduction in the probability of dying in the first 28 days of life.

FIGURE 2 HERE

Figure 3 stratified this analysis to examine how the relationship between interval length and age has changed over time. These figures only refer to the FE estimates. The nonlinear nature of this relationship has persisted across birth cohorts, but as was suggested by the predictions in figure 1, it is weakening. The magnitude of the effect has been decreasing for births to women of all ages and for all cohorts. It also was consistently the strongest for young women. For children born in the 1970s, increasing a birth interval by one year for a teenage mother would have reduced neonatal mortality risks by over 0.02. The effect on a child born to a young mother between 2000-2009 was only about 0.012. The curves can be seen slowly moving towards zero, especially for women giving birth in their mid-twenties. For women above age 40 (not shown here), the marginal effect in fact overlapped with zero, but due to the small number of observations at higher ages, these estimates should be treated with some caution.

FIGURE 3 HERE
Variation across Maternal Education

Finally, I examine heterogeneity in the effect of birth interval length on neonatal mortality risks with respect to maternal education. Figure 4 once again shows the effects of interval length by maternal age, but is now stratified by maternal education. There is a clear educational gradient in the strength of the effect whereby children born to women with no education could benefit the greatest from longer birth intervals and those born to women with secondary or higher education experience almost no marginal benefit from longer spacing. The intermediary levels of education fall within this range. Young women with no education or only primary education would benefit the most by increases in birth spacing, while the effect is fairly flat across ages for women with only some primary education. For women with secondary education or more, a significant effect can only be identified for those giving birth in their thirties. Otherwise, the estimates are statistically indistinguishable from a null effect.

FIGURE 4 HERE

Turning to educational differences across birth cohorts (Figure 5), it can be seen that the importance of birth interval length as a determinant of neonatal mortality has weakened over time for all educational groups but for women with some secondary or higher education. It has occurred, however, at different paces. Among the most highly educated mothers, the marginal benefit of birth spacing on neonatal mortality risks has been indistinguishable from zero for decades. For the other educational groups, however, we can see a sequential disappearance of the effect. By around the turn of the century, the relationship between interval length and mortality becomes statistically insignificant for women with some primary schooling and for those completing primary schooling. Among those with no education, the effect only reaches zero towards the end of the observation period.

FIGURE 5 HERE

DISCUSSION

The results of the analysis showed how the effect of birth spacing on neonatal mortality risks varies along several dimensions. First, the relationship has been weakening over time. Given the causal mechanisms responsible for the relationship, this was to be expected as overall levels of mortality have declined in Bangladesh since the 1970s. For more recent birth cohorts, there was not even a
statistically significant effect of interval length on mortality, but the average effect hides considerable heterogeneity.

An important source of heterogeneity observed in this study is that this relationship is highly dependent on a mother’s age at birth. A benefit of longer intervals on mortality risks was found among all age groups, indicating that it is indeed a necessary element in any family planning initiative. Yet a consistent finding was that young mothers could benefit the most. It is the children of teenage mothers and those in their early twenties, specifically, who would experience the largest improvements in survival probabilities from longer intervals. The age-specific pattern, despite changes in the magnitude of the relationship, was a consistent finding across birth cohorts. This is no trivial result, as Bangladeshi women reproduce at very young ages. According to the 2014 Bangladesh DHS, almost 40% of currently married women under 25 had already progressed to their second or higher order birth (National Institute of Population Research and Training (NIPORT) et al., 2016). This risk factor is thus highly relevant to the Bangladeshi context.

Another significant finding was that the survival prospects of children born to less-educated women are influenced to a greater degree by the length of the preceding birth interval. Across birth cohorts, women with no education also were the last to see this relationship converge towards a null effect. But real differences still remain and were largely relegated to women giving birth at young ages. At older ages, there did not appear to be any substantial differences across educational groups other than for the most highly educated. It is important to realize that the group with no education makes up a substantial share of Bangladesh’s female population. In the present sample, they account for over half of all women, though this is largely due to very low levels of education among women at older ages. Nevertheless, even among those born after 1990, over 20% have less than a primary school education. Again, this is not merely a marginal group that is at a heightened risk, but a substantial part of the population.

These findings have important implications for family planning strategies in Bangladesh. First and foremost, these findings reinforce the necessity to communicate the importance of birth spacing to all women, as there was a significant mortality-reducing effect of longer intervals. This recommendation has gained momentum in recent years and should continue to be a part of communication strategies. There is now a substantial body of research in support of this position (see Conde-Agudelo et al., 2012). Until now, however, it had not been shown that some individuals stand even more to gain from birth spacing than others.
The second major implication of this study is that this information must be more intensely targeted at young women and their husbands. Women giving birth below age 25 saw larger reductions in neonatal mortality rates associated with birth interval length compared to those at older ages. There are some unique challenges with reaching these women, however. They tend to have the greatest unmet need for family planning for birth spacing purposes, yet the traditions of teenage marriage and patriarchy in Bangladesh restrict young women’s decision making capabilities. Teenage married women are much less likely to be able to visit health facilities without being accompanied by their husband, for example. Family planning programs in Bangladesh have indeed acknowledged these issues for a long time. Learning from early failed attempts to increase contraceptive uptake in the 1970s (Cleland et al., 1994), family planning programs in Bangladesh may be viewed as an example of a successful attempt to fit programs to local cultural norms in order to maximize their effectiveness. They have attempted to address them through the household delivery of contraceptive advice and services by literate female workers and by galvanizing the support of local elites and religious leaders (Cleland et al., 1994; Simmons, Baqee, Koenig, & Phillips, 1988).

Despite achieving much progress, there remain challenges in addressing the power imbalances within relationships that often lead to higher unmet among young women and women with less education. Generally speaking, there are two approaches adopted to address power imbalances: woman-centered and couple-centered approaches. Most family planning strategies have been largely focused on women and attempt to encourage family planning by circumventing monetary and social costs of contraception through service delivery, mass media campaigns, social marketing, and increasing the supply of contraceptives. These initiatives should not be overlooked, because their impact has been substantial (Bongaarts, 2014), but this approach has been criticized as many goals of modern family planning programs, like those concerning maternal and child health, require the active participation of both spouses (Becker, 1996). Furthermore, the woman-centered approach places emphasis on using contraceptives that only require women’s participation, such as hormonal methods, which are often viewed with skepticism and caution as they are perceived as disruptive to the bodily processes (Salway & Nurani, 1998). A woman-centered approach is also weaker in addressing certain barriers towards the practicing of family planning. Because of married women’s overwhelming dependence on their husbands in Bangladesh, the threat of divorce or desertion weighs heavily on any decision that may violate their husband’s wishes. Even the perception that a husband is opposed to family planning may has been shown to be enough to
dissuade a young woman from adopting contraception, and the apparent apathy of men towards their wives’ contraceptive choices does little to quell these fears (Schuler et al., 1995).

One possibility for addressing gender inequality in relationships is to break the financial dependence of women from men. A common tool thought to address this is microcredit, which has been issued extensively in Bangladesh. One well-known study has shown that access to microcredit empowered Bangladeshi women by increasing their economic contribution to household, political and legal awareness, physical mobility, and political participation (Hashemi, Schuler, & Riley, 1996). But evidence supporting the empowering effect of microcredit is mixed. It has been shown, for example, that microcredit transfers tend to be appropriated by husbands and ultimately do little to increase women’s independence (Goetz & Gupta, 1996). This approach may be ineffective without addressing the cultural roots of the patriarchal system that restricts young women’s abilities to satisfy their demand for contraception.

An alternative possibility is to treat men’s behavior and attitudes as an equally important component to those of women in family planning programs and this has resulted in attempts to enlist men’s support by including them in programs’ overarching strategies. Previous research has indeed shown that Bangladeshi women who have their husbands’ approval for family planning or are in more equalitarian relationships are more likely to adopt contraception and less likely to have an unmet need for contraception (N. Kamal, 2000; S. M. M. Kamal & Islam, 2010; Uddin, Pulok, & Sabah, 2016). It has been a challenge, however, to engage husbands, which may be especially important when discussing young married women who have significantly less bargaining power in a relationship compared to those at older ages. The difficulty of fostering men’s participation is not unique to Bangladesh, and has been observed in other developing contexts (Ditekemena et al., 2012). Some evidence suggests that men wish to be included in these programs and are eager to learn more about family planning (Blanc, 2001), but it is not yet clear if this approach is actually a more effective strategy for changing contraceptive use than targeting women alone. In certain contexts, men who are included in family planning strategies tend to more openly communicate with their wives and have greater levels of contraceptive use (Shattuck et al., 2011; Wang, Vittinghoff, Hua, Yun, & Rong, 1998), but in others there seems to be no advantage over women-centered strategies (El-Khoury et al., 2016). There have been relatively few randomized control trials of these sorts of interventions in modern developing contexts, however. This may be a promising path forward towards addressing the cultural roots of gender inequality within marriages.
that lead to greater unmet need among young and low educated women. In turn, this could have a substantial impact on neonatal mortality rates by increasing mean birth intervals of younger women.

CONCLUSION

This study is the first to show that the well-known relationship between birth spacing and neonatal mortality is not uniform across birth cohorts, ages, or educational groups. On average, the effect of birth spacing on mortality risks is approaching zero in Bangladesh, but heterogeneity in the effect still persists. I have identified that children born to young and low educated women are disproportionately impacted by the length of the preceding birth interval. By using a within-family approach, the possibility that these differences are driven by unobserved compositional differences across mothers is eliminated. In other words, the differences in the magnitude of the effect over time, age, and education are not driven by the fact that mothers giving birth in a certain year, at young ages, or with low education are somehow different from those with different characteristics for unobserved reasons. The results suggest that family planning programs that more specifically target these high-risk groups may help to accelerate the decline of neonatal mortality. There are serious challenges in reaching these specific groups, however, as strong norms of patriarchy tend to disproportionately limit the freedom of these women. Future family planning strategies will need to find a way to address this issue.
REFERENCES


UNICEF. (2016). *From the First Hour of Life*. Retrieved from New York:


### TABLE 1. Descriptive Statistics of Analysis Sample from BMMS 2010.

<table>
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<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
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<td><strong>Mothers</strong></td>
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FIGURE 1. Marginal effect of birth interval length on neonatal mortality risks by birth cohort

NOTE: Figures reflect the change in the probability of neonatal mortality associated with a one year increase in the length of the preceding inter-birth interval. The left panel presents predictions under the assumption that there is no family-specific unobserved heterogeneity. The right panel are the predictions after adjusting for maternal fixed effects. All covariates held constant at their mean values.
FIGURE 2. Marginal effect of birth interval length on neonatal mortality risks by maternal age at birth

NOTE: Figures reflect the change in the probability of neonatal mortality associated with a one year increase in the length of the preceding inter-birth interval. The left panel presents predictions under the assumption that there is no family-specific unobserved heterogeneity. The right panel are the predictions after adjusting for maternal fixed effects. All covariates held constant at their mean values.
FIGURE 3. Marginal effect of birth interval length on neonatal mortality risks by maternal age at birth over time.

NOTE: Figures reflect the reduction in the probability of neonatal mortality associated with a one year increase in the length of the preceding inter-birth interval. The panels refer to births occurring within the specified years. All covariates held constant at their mean values.

NOTE: Figures reflect the reduction in the probability of neonatal mortality associated with a one year increase in the length of the preceding inter-birth interval. All covariates held constant at their mean values.
FIGURE 5. Marginal effect of birth interval length on neonatal mortality risks by maternal education and birth cohort.

NOTE: Figures reflect the reduction in the probability of neonatal mortality associated with a one year increase in the length of the preceding inter-birth interval. All covariates held constant at their mean values.
APPENDIX

TABLE 1A. Estimates from OLS and Mother FE models of birth interval length on neonatal mortality risk.

<table>
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<tr>
<th>Preceding Interval Length</th>
<th>OLS</th>
<th>Mother FE</th>
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<tr>
<td>&lt;18 months</td>
<td>(ref)</td>
<td>(ref)</td>
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<tr>
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<td>-0.015</td>
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<td>24-29 &quot; &quot;</td>
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<td>36-41 &quot; &quot;</td>
<td>-0.056</td>
<td>-0.027</td>
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<tr>
<td>42-47 &quot; &quot;</td>
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<td>-0.029</td>
</tr>
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<td>48-53 &quot; &quot;</td>
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<tr>
<td>54-59 &quot; &quot;</td>
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<tr>
<td>60+ &quot; &quot;</td>
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<td>-0.021</td>
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<tr>
<td>Age at Birth²</td>
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<td>0.001</td>
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<td>Age at Birth³</td>
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<td>0.000</td>
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<tr>
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<td>Birth Year²</td>
<td>0.000</td>
<td>0.000</td>
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<tr>
<td>Birth Order</td>
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<td>2</td>
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<td>3</td>
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<td>4</td>
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<td>7</td>
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<td>8</td>
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<td>Constant</td>
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</tr>
</tbody>
</table>

| Mothers                   | 79,576    | 79,576    |
| Children                  | 263,435   | 263,435   |
| F-statistic               | 395.1     | 878.3     |
| R²                        | 0.043     | 0.123     |

Note: R² for mother FE model refers to within-R². Models estimated as Linear Probability Models. Models used in analysis use a continuous operationalization of the preceding interval length. The variable was categorized here to aid interpretation.