Supporting Information

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SI Text

Fertility Decline in Bangladesh. The demographic transition in Bangladesh has been studied since the early 1980s, often in terms of the efficacy of family planning programs. Early research in Matlab focused on cultural transmission (1), proposing that fertility reductions occurred through the Community Health Research Workers, local women who visited households regularly to deliver family planning services, do health assessments, and actively work to change people's perceptions of ideal family size and acceptance of contraception. Other studies have found diffusion effects for contraceptive use rates (2), changes in ideal family size (3–5), changes in women's roles (6), and changes in cultural values (7). Collectively, these studies suggest that fertility in Matlab and Bangladesh has been reduced through diffusion processes.

In contrast, other studies have found economic factors including women's education and the presence of schools to be significant predictors of fertility reduction (8–13). Additionally, Kabeer (12) suggests that many of the social changes observed in cultural transmission studies are the result of economic pressures from Bangladesh's exploding population, which has reduced the availability of arable land, thus motivating parents to reduce the number of heirs. Risk reduction models have not been commonly used to explain the demographic transition in Bangladesh, although Hossain et al. (14) find that infant deaths reduce birth spacing and may increase overall fertility levels in six regions.

Comparative studies (15, 16) find that the majority of observed reduction in fertility levels can be attributed to the effects of female education, female employment, and access to media on contraceptive use. Neither study can point to which set of factors is primary, however, nor do they take into account the effects of mortality or risk.

Explanation of Variables. ***General notes on sample and variables.*** Data were collected from April to August 2010. Respondents were women drawn from a full list of all members of the eligible study population, including all women aged 20–64 y in the International Center for Diarrheal Disease Research, Bangladesh (ICDDR,B) Health and Demographic Surveillance System, a population of more than 65,000 women. Women were drawn with equal probability from within the ICDDR,B Area and the Government Service Area, and also from within each of three 15-y age categories (20–34, 35–49, and 50–64), allowing for better representation of older women who would otherwise be underrepresented owing to rapid population growth.

Our data are censored because younger women in our sample may not yet have commenced or completed fertility. Survival analysis was not feasible owing to data constraints with respect to the timing of women's births, thus we deal with potential censorship in three ways. First, we include controls for age and age at marriage in all models to adjust for primary effects of fertility timing. Second, we limit the sample to married women. There is very little nonmarital fertility in our study population owing to early marriage, strong taboos against premarital sex, and social segregation of the sexes (especially before marriage). We thus consider unmarried women not at risk for fertility and exclude them from these analyses. Five divorced or widowed women with no children are also excluded from the sample. Third, we deal with the potential effects of censorship by limiting the sample to women who have been married 5 y or more. In other words, we exclude newlyweds who are the least likely to have completed (or even commenced) fertility. Finally, given the current fertility trend for women to have two to three children in the first several years of their marriage before stopping altogether, it is likely that the majority of women older than 30 y have completed their fertility. Thus, only a small fraction (5%) of the women in our sample are likely to be at high risk of further childbearing because they are younger than 30 y and have fewer than two children.

Our survey included questions on a broad range of topics related to fertility, and women were asked to answer questions relating to their childhoods as well as their life after marriage. All categorical variables use scales suggested by open-ended interviews and adjusted by researchers after extensive pretesting of survey questions and examination of survey data. Descriptions of all variables included in the final models, as well as lists of variables investigated but excluded, follow. Summary statistics for included variables are shown in Tables S1 and S2.

Outcome and control variables. (*i*) Total Fertility: Count variable, given by the respondent (i.e., the woman included in our survey) then checked against existing demographic data. The woman's total number of live births, a commonly used proxy for fertility in the demographic literature (Fig. S1). (*ii*) Surviving Children: Count variable, given by respondent, checked against existing demographic data. The woman's total number of children currently surviving or having lived past age 10, a commonly used proxy for fertility in the evolutionary anthropology literature (Fig. S1). (*iii*) Age: Continuous variable, calculated from existing demographic data and confirmed via interview with respondent. Used as a control variable in all models including the base model. (*iv*) Age at Marriage: Continuous variable, given by respondent and checked against date of marriage (if known) in existing demographic data. Used as a control in all models, including the base model. This is a key control because fertility risk begins at marriage in this culture, thus the length of time since marriage is a key correlate of both fertility and the risk of fertility. Although some older women in this sample were married as young as age 7 y, because the purpose of this variable was to adjust for time at risk for fertility, age at marriage was adjusted to 11 y for all women married younger than 11 y because this is the youngest age at which pregnancy is likely to be possible. As discussed above, newlyweds (women married less than 5 y) were excluded from the sample.

Risk/mortality variables in model. (*i*) Number of Child Deaths in the Marital *Bari*: Continuous variable, given by respondent. The number of child deaths occurring in the respondent's marital bari (patrilineal neighborhood), or the bari/area where she lived after marriage, since the time of her marriage other than the deaths of her own children. Higher number of child deaths in the marital bari are associated with higher fertility. (*ii*) Infant Mortality Rate in the Respondent's Year of Marriage: Continuous variable, determined from publicly available ICDDR,B annual reports. The infant mortality rate is calculated annually out of 1,000 children born. Higher infant mortality rates are associated with higher fertility. (*iii*) Woman in Intervention Area: Categorical variable, determined from sample based on respondent's location. This variable was recorded as a 1 if the respondent resided in the ICDDR,B area and as a 0 if she did not. A program providing free maternal and child health care, free access to frequently needed treatments such as oral rehydration therapy, and hospital care for severe illness was introduced in the ICDDR,B intervention area, comprising roughly half the study population, in 1978. At this time our oldest respondents would have been in their early 30s, and many of them would still have been bearing children. Similar, although often more limited, programs were introduced in the nonintervention area by the Bangladeshi government or other nongovernmental organization in the 1980s and 1990s—thus women in the intervention area have experienced longer and more reliable exposure to better health care than have women in the nonintervention area. Residence in the intervention area is associated with lower fertility. This variable is also a proxy for access to contraception and family planning messages (details in *Cultural transmission variables in model*, below). (*iv*) Life Expectancy at Birth in the Respondent's Year of Marriage: Continuous variable, determined from publicly available ICDDR,B annual reports. Higher life expectancy at birth is associated with lower fertility before controls and higher fertility when mortality controls are included in the model.

Risk/mortality variables not retained. Additional risk/mortality variables examined but eliminated from final models based on model selection criteria include the following: child and adult deaths in the respondent's natal bari; adult deaths in the respondent's marital bari; woman's level of childhood food insecurity; woman's frequency and severity of recent and childhood illnesses; woman's perception of several different types of risks, including child morbidity and mortality, adult morbidity and mortality, and the frequency of accidents and violence in the community; and whether the woman was in her childbearing years during any of four major mortality shocks (the 1971 Liberation War, a devastating flood and famine in 1974–1975, a large shigellosis epidemic in 1984, and a cholera epidemic in 1991–1992).

Economic/investment variables in model. (*i*) Whether the Family Owns Land: Categorical variable, given by respondent. This variable was recorded as a 1 if the respondent and her husband owned any land and as a 0 if they did not. Amount of land owned was also collected but did not improve the fit of the model. Land ownership is associated with higher fertility. Several authors have linked land ownership to fertility (12, 17, 18). (*ii*) Family Engaged in Agriculture: Categorical variable, given by respondent. This variable was recorded as a 1 if the respondent's husband or the respondent herself were engaged in agriculture as a primary or secondary occupation and recorded as a 0 if they were not. Engagement in agriculture is associated with higher fertility. (*iii*) Woman's Level of Education: Continuous variable, given by respondent. Level of education was collected as years of education; most women have no education (n = 313) or primary education only (n = 268), with smaller numbers of women having secondary education (n = 199) and only a few women having more than secondary education (n = 17). Although a categorical version of the variable was tried, the continuous version was more parsimonious. Many economic models of fertility emphasize the increasing costs and importance of investment in education in reducing fertility. Higher levels of education are associated with lower fertility even when age at marriage is controlled. This variable is also included in *Cultural transmission variables in model*, below. (*iv*) Husband's Occupation: Categorical variable, given by respondent. Primary occupation of the respondent's husband, categorized using data from qualitative interviews to reflect the degree of engagement with a modern market economy: 0 = farmer/fisherman (limited engagement) or laborer (moderate engagement), 1 = business owner (moderate to high engagement) or salaried worker (high engagement). A four-category version of the coding was tried but found to be less parsimonious. More market-engaged types of occupations are associated with lower fertility. (*v*) Household Income: Logged continuous variable, given by respondent. Combined monthly income of husband and respondent from all sources in Bangladeshi Taka, logged to adjust for high variance and right skew. Higher income is associated with higher fertility once education is controlled.

Economic/investment variables not retained. Additional economic/investment variables examined but eliminated from final models based on model selection criteria include the following: husband's education; costs of child education; whether the woman worked outside the home after marriage (women are rarely used outside the home in this sample, so a more detailed measure was not feasible); marriage costs of the woman and her husband (a measure of both wealth and direct investment in the new family by the couple's parents); the time the woman spent with her own mother or father when she was a child (a proxy for direct investment by parents); the time the woman and her husband spend with their oldest son and daughter; the amount of land owned by the woman and her husband; and whether the woman's household participated in a microcredit program.

Cultural transmission variables in model. (*i*) Woman's Level of Education: Continuous variable, given by respondent. Many models of fertility decline argue that information or social norms learned in school may encourage reduced fertility. Higher levels of education are associated with lower fertility. This variable is also included in *Economic/investment variables in model*, above. (*ii*) Woman in Intervention Area: Categorical variable, determined from sample based on respondent's location. This variable was recorded as a 1 if the respondent resided in the ICDDR,B area and as a 0 if she did not. A program providing free access to contraceptives, education on how to use them, and messages from health workers that family limitation was important for family happiness, well-being, and child health was introduced in the ICDDR,B intervention area, comprising roughly half the study population, in 1978. At this time our oldest respondents would have been in their early 30s, and many of them would still have been bearing children. Similar, although often more limited, programs were introduced in the nonintervention area by the Bangladeshi government or other nongovernmental organization in the 1980s and 1990s—thus women in the intervention area have had longer and more reliable exposure to both contraception and family planning messages than have women in the nonintervention area. Residence in the intervention area is associated with lower fertility. This variable is also a proxy for greater access to health care (details in *Risk/mortality variables in model*, above). (*iii*) Location of Husband: Categorical variable, given by respondent. Husband's location was used as a proxy for exposure to potential low-fertility social norms associated with professional occupations, high status, and urban residence. The variable was coded as follows: 1 = in Matlab (limited exposure), 2 = in Dhaka or another Bangladeshi city (moderate exposure), and 3 = abroad (high exposure). Residence of the husband in cities or abroad was associated with increasingly low levels of fertility. Although part of this effect may be due to physical absence, several lines of data suggest that low fertility among labor migrants is intentional. Labor migrant grooms marry early and plan long visits home with the goal of getting their wives pregnant, and in qualitative interviews respondents often discussed the fact that higher levels of education, higher status jobs, and better marriages for children are made possible by labor migration and fertility reduction. (*iv*) General Fertility Rate in Respondents' Year of Marriage: Continuous variable, determined from publicly available ICDDR,B annual reports. The general fertility rate (GFR) is a count of the number of births per year per 1,000 women, used here as a proxy for prevailing social norms regarding fertility. A high GFR is associated with higher individual fertility. (*v*) Index of Exposure to Modern Media: Continuous variable, calculated based on data given by respondent. This variable draws on questions about exposure to modern media including television, radio, newspapers, books, posters, or billboards for both the respondent and her husband using an eight-category temporal scale from never to daily. Categories were collapsed into statistically meaningful units, then entered into a factor analysis. The first principal component was taken and used as a measure of media exposure in model comparison analyses; this version of the variable had moderately better predictive power than versions using an additive index or including the second principal component. Although consistent with predictions a bivariate correlation suggests greater media exposure is associated with lower fertility, in the presence of the other variables (notably woman's age) higher exposure to media is associated with higher fertility.

Cultural transmission variables not used. Additional cultural transmission variables examined but eliminated from final models based on model selection criteria include the following: number of people in the natal or marital bari living abroad; whether the woman, her husband, or her mother or father had visited Dhaka or Matlab bazaar (frequency of visits was also tried); the woman's frequency of conversations about contraception with husband, all kin, or anyone; whether the woman's mother used contraception; the woman's attitude toward contraception; the number of the woman's and husband's siblings; the woman's and husband's religion (Muslim, Hindu, or other); the distance between the woman's natal and marital bari (a proxy for the potential influence of her natal kin); and whether the woman's household participated in a microcredit program.

Full Inclusive Model Results. As described in *Methods*, we used the glmulti package to model each outcome variable against all combinations of the 12 independent variables and control variables. An exhaustive search of more than 16,000 models (drawing all possible subsets of variables) found the models with the lowest AIC values, which we report in Table 4. In Table S3, we summarize the global results, including importance values for all 12 variables. We also report the number of times each variable appeared in one of the 50 models with the lowest AIC values; these models all had an AIC difference of 10 or less compared with the best model. [Models with AIC differences over 10 have essentially no support from the data (19).]

Temporal Change and Equilibrium. Some theoretical models that make predictions about fertility make the simplifying assumption that the system is at equilibrium, a condition that is rarely met in human samples (20). This is true of some risk models (21), some economic models (22, 23), and even of the more formal cultural models (24). The Matlab system is clearly not at equilibrium—in fact the phenomenon of interest is the result of change. Consequently, some variables may not explain as much as others because women cannot use them to make predictions about future environments. This issue has been noted specifically with mortality risk, but it is also true of economic and social change and thus in our case should not systematically affect the interpretation of one set of variables compared with the others. Moreover, although economic models may prevail in our model comparison results, variables from all model classes are represented in the best inclusive model.

Our analysis also addresses temporal changes in several ways. First, we include age and age at marriage in all models as controls for temporal differences. Second, values of temporally changing predictors are based on each respondent's year of marriage, increasing the specificity of such predictors for each individual woman. Third, because the reproductive spans of women in the sample range from 5 to 15 y, the amount of change from the start to end of a woman's reproductive period is much less than that occurring over a lifetime or over the research period as a whole. This means that individual women's reproductive spans are much closer to being at equilibrium than the sample is as a whole. Women need to rely on some cues to behavior, and although these may change over time, cues chosen very close to the start of reproduction are less likely to be subject to problems related to temporal change. Finally, most temporally adjusting predictors in our sample show clear directional trends. Although the values for particular years may fluctuate, most annual values will be clearly associated with the directional change as a whole. This reduces the problems with prediction associated with temporally changing variables.

Feedback and Interactions Between Model Classes. Several of the strongest predictors in our models are variables that tap into more than one causal pathway. Variables such as a woman's education, residence in the intervention area, and the location of the respondent's husband may exhibit a combination of economic and cultural transmission effects. Women's education is consistently one of the strongest predictors of fertility cross-culturally as well as a key component of both economic and cultural models of fertility decline. Qualitative data from our study suggest that the primary motivations for educating daughters are economic, including providing employment options in case of divorce, improving their position on the marriage market, and helping them better educate their own children. It is also clear, however, that women gain knowledge of low fertility social norms and information on health and child welfare when they are at school. Kaplan (23) argues that although increased investment in human capital may reduce fertility, cultural transmission of low fertility ideals could follow and exaggerate this effect creating a more dramatic fertility decline; a related argument has been made by Boyd and Richerson (24). Our data are consistent with such interpretations.

Other variables suggest a potential interaction between risk and cultural transmission factors. An important example is residence in the intervention area, associated with key aspects of cultural transmission, including access to free contraception accompanied by family planning information and training. However, living in the intervention area is also associated with risk reduction, because intensive health-related programs were introduced in this area during the same period and were often communicated through the same individuals. These health programs have changed the cost/benefit analysis of women living in the area as mortality reductions made them less likely to experience child mortality (25). The effects of these two types of interventions are difficult to disentangle from one another: although they have short-term effects that may counteract each other—contraception reducing fertility and health interventions increasing the number of surviving children—in the longer term both effects have likely decreased fertility through risk and cultural transmission mechanisms.

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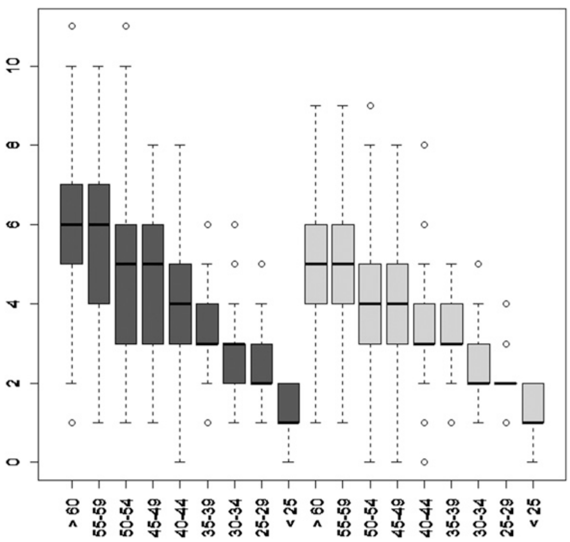

Fig. S1. Boxplots of total fertility (dark gray bars) and surviving children (light gray bars) by mother's age (n = 799).

Table S1. Summary statistics for continuous variables (n = 799 women)

Variable	Mean	SD	Median	Range	Direction
Dependent variables					
Total fertility (births)	4.00	2.04	4	0 to 11	
Surviving children (children)	3.56	1.69	3	0 to 9	
Control variables					
Woman's age (y)	43.67	11.27	44	21 to 67	+
Woman's age at marriage (y)	16.25	3.05	16	11 to 35	–
Risk/mortality variables					
Number of child deaths in bari	1.56	1.87	1	0 to 15	+
Infant mortality rate (per 1,000)	103.0	30.51	112.80	39.1 to 146.8	+
Life expectancy at birth (y)	52.5	4.61	52.29	43.7 to 62.1	+
Economic/investment variables					
Household income (Taka per year logged)	11.07	1.05	11.18	6.7 to 14.9	+
Woman's education (y)	3.63	3.69	3.00	0 to 16	–
Cultural transmission variables					
Woman's education (y)	3.63	3.69	3.00	0 to 16	–
General fertility rate (births per 1,000)	152.50	35.44	157.60	88.7 to 219.2	+
Index of exposure to modern media	−0.06	0.98	−0.18	−1.60 to 3.08	+

Table S2. Summary statistics for categorical variables, n = 799 women

Parameter	n	Direction
Risk/mortality and cultural transmission variable		
Woman in intervention area		
0 = No	466	Reference
1 = Yes	333	–
Cultural transmission variable		
Location of husband		
1 = in Matlab	571	Reference
2 = Dhaka or other city	138	–
3 = Abroad	90	–
Economic/investment variables		
Whether family owns land		
0 = No	205	Reference
1 = Yes	594	+
Family engaged in agriculture		
0 = No	409	Reference
1 = Yes	390	+
Husband primary occupation		
0 = Agriculture or day labor	390	Reference
1 = Business or salaried	409	–

Table S3. Inclusive models with all independent variables

Variable*†	Sign	Importance	n in top 50
Total fertility			
Child deaths in bari (R)	+	1.00	50
Whether family owns land (E)	+	1.00	50
Woman in intervention area (R, C)	–	1.00	50
Woman's level of education (E, C)	–	0.98	49
Husband's occupation (E)	–	0.94	46
Household income (E)	+	0.63	30
Life expectancy at birth‡ (R)	+	0.62	31
Family engaged in agriculture (E)	+	0.51	26
Infant mortality rate‡ (R)	+	0.48	24
Husband's location (C)	–	0.40	20
General fertility rate (C)	+	0.28	17
Exposure to modern media (C)	+	0.01	1
Surviving children			
Whether family owns land (E)	+	1.00	50
Family engaged in agriculture (E)	+	1.00	50
Child deaths in bari (R)	+	1.00	50
Woman in intervention area (R, C)	–	0.85	41
Household income (E)	+	0.63	31
Infant mortality rate‡ (R)	+	0.52	27
Woman's level of education (E, C)	–	0.39	20
General fertility rate (C)	+	0.39	20
Husband's occupation (E)	–	0.25	13
Exposure to modern media (C)	+	0.14	8
Husband's location (C)	+	0.09	5
Life expectancy at birth‡ (R)	+	0.05	3

R refers to a risk/mortality variable, E refers to an economic/investment variable, and C refers to a cultural transmission variable.

*Variables are listed in order of importance.

†Woman's age and age at marriage are included as control variables in all models.

‡Figure given for the year of the woman's marriage, when childbearing is likely to begin.