

Early Marriage, Age of Menarche and Female Schooling Attainment in Bangladesh

April 2008

Abstract: This paper provides empirical evidence of the influence of adolescent marriage opportunities on female schooling attainment and gives predictions of the impact for imposing universal age-of-consent laws. Using data from rural Bangladesh, we explore the commonly cited hypotheses that women attain less schooling as a result of social and financial pressure to marry young. We isolate the causal effect of marriage timing by exploiting variation in the timing of menarche as an instrumental variable for age of first marriage. Our results indicate that marriage age matters: Each additional year that marriage is delayed is associated with 0.22 additional years of schooling attainment and 5.6% higher probability of literacy. Delayed marriage is also associated with a significant increase in use of preventive health care services, some of which appears to be independent of the change in schooling, indicating separate “age effects” of delaying marriage. In the context of competitive marriage markets we show that the above results can be used to obtain estimates of the change in equilibrium female education that would arise from introducing a minimum legal age of marriage. The resulting analysis implies that, under reasonable assumptions, enforcing universal age of consent laws would have a strong positive impact on female schooling.

JEL Classification: I32, I12, J12, J13, J16, O12

Keywords: Marriage, matching, fertility, education, gender

1 Introduction

In much of the developing world, adolescent and child marriage continues to be a strong social norm, particularly for girls. Early female marriage is associated with a number of poor social and physical outcomes for young women and their offspring. On average, girls who marry as adolescents attain lower schooling, have lower social status in their husbands' families, report less reproductive control, and suffer higher rates of maternal mortality and domestic violence.¹ In addition, these individual outcomes suggest a number of larger social consequences of early marriage, including higher population growth, more rapid spread of disease, and a higher incidence of orphans.

As a result of these patterns, governments in developing countries face increasing pressure to eradicate the practice with legal sanctions against parents who marry daughters before a standard age of consent. Proponents of age of consent laws argue that forcing parents to delay marriage will increase female schooling attainment and reproductive control, and decrease incidence of domestic violence, and social programs increasingly contain program rules designed to discourage the practice. For instance, a prominent micro-finance program in India excludes parents who marry daughters before 17, and national education vouchers in Bangladesh exclude married girls. However, while statistics indicate that women who marry young fare worse, it is difficult to assess the extent to which these outcomes are driven by the timing of marriage as opposed to common factors related to poverty and traditional gender views that also hinder female advancement. Given that child marriage is most common in impoverished and culturally traditional settings, the observation that women who married young have on average less education does not imply that forcing girls to postpone wedlock would improve their outcomes.

This paper attempts to shed light on the issue by studying the schooling consequences of early marriage for girls in rural Bangladesh, an area with one of the highest rates of child marriage worldwide. Since it is also an environment of rapidly expanding schooling opportunities and returns to education for girls, adolescent marriage is frequently blamed for the persistent gender gap in schooling attainment. To estimate the influence of marriage practices on girls' schooling we employ a two-step methodology. In the first step we measure changes in schooling investment that result from a random subset of girls being forced to postpone marriage. In particular, we make use of variation in the timing of menarche as an instrumental

¹ Jensen and Thornton (2003) provide a recent overview of these patterns worldwide.

variable (IV) for age of first marriage. The idea behind this identification strategy is the following: While there are frequently incentives to marry daughters as young as possible, in Bangladesh as in many parts of the world girls are typically withheld from the marriage market until the onset of puberty. This institutional feature in the context of high rates of very early marriage presents a binding constraint on exposure to adolescent marriage opportunities. In particular, natural variation in the timing of first menstruation within the age range of 11 to 16 generates quasi-random differences in the earliest age at which girls are at risk of marrying.² Our estimates indicate that each additional year that menarche is delayed postpones marriage 0.74 years. This physical barrier to younger marriages, in so far as it is independent of schooling investment, presents a unique opportunity to assess the effects of child marriage on female education outcomes.

The validity of the IV strategy depends on potential unobservable differences in family background influencing both adolescent maturation and adult outcomes. Survey data on parents' wealth as well as adult height and health indicators reveal no significant differences in family background according to age of menarche within the age range to which we restrict our estimates. More importantly, this bias would work against our central findings. Hence, the results may underestimate parents' increase in schooling investment that arises from delayed marriage.

We also present evidence that reaching menarche indeed affects schooling through marriage decisions rather than through a direct effect by comparing the influence of delayed puberty on marriage and schooling according to sex-specific birth order. We show that, on account of traditionally strong preference for marrying daughters in order of birth, menarche has very little influence on marriage when a girl has many older sisters and the influence of menarche on marriage declines continuously with sex-specific birth order conditional on total number of female siblings. We then test whether the direct effect of menarche on schooling attainment follows a similar pattern according to sex-specific birth order. The logic here is that, while number of older relative to younger sisters determines how quickly a girl can marry, it should not be related to religious or social attitudes of the girl's family that could induce them to take a daughter out of school after she reaches puberty. Hence, if the relationship between menarche and schooling is driven by parents' preference to remove girls from school at puberty, the influence of menarche on schooling attainment should be independent of birth order. Put

² See Palmert and Boepple (2001) for a discussion of distributions of age of menarche across populations.

differently, if the effect is driven by a change in female behavior at puberty, the treatment effect of puberty on schooling should vary *across* households, based on some characteristics such as religiosity, and not vary *within* households based on individual characteristics such as birth order. Instead, the direct influence of menarche on schooling is nearly twice as large for eldest siblings and is sensitive to age gaps between female but not male siblings. We also show that the effect of menarche on schooling is independent of whether a woman follows restrictions on dress that traditionally begin at the onset of puberty. Hence, there is no evidence that our effects are disproportionately high among girls from more traditional or religious households, as would be anticipated if the effect were driven by adherence to social customs.

In the second stage of the analysis we show how the previous empirical results can be used for macro-level policy analysis. The IV estimates correspond to how a change in a woman's individual constraint affects her schooling attainment. In contrast, an age of consent law imposes a universal constraint on marriage choices, which gives rise to potentially complicated equilibrium adjustment effects with ambiguous direction of influence. The regulation induces a change in the equilibrium amount of monetary transfers that brides of different ages have to pay when they marry, which in turn can change marriage age decisions of even those women who were not directly affected by the change (who in the absence of regulation would have married at an older age). However, we provide a simple condition on preferences under which the equilibrium adjustment is very simple: those women who would marry younger than the minimum legal age in the absence of regulation marry exactly at the minimum legal age if the restriction is imposed, while the marriage age decisions of all other women are unaffected. The condition requires that women can be ordered with respect to their incremental utilities from marrying a year later and men can be ordered with respect to their incremental (dis)utilities from marrying a bride who is a year older, a plausible assumption in the setting under study. The resulting equilibrium adjustment procedure implies that our empirical estimates can be used to predict the impact of age of consent laws since the effect of a universal constraint on a woman's marriage age is identical to her facing the same individual constraint.

The results we obtain indicate that female schooling is substantially constrained by marriage opportunities at young ages. One year postponement of marriage between the ages of 11 and 16 increases schooling by an estimated 0.22 years and adult literacy by 5.6%. Correspondingly, at the aggregate level we estimate that legally restricting marriages below age

17 would increase average female schooling by a minimum of 0.58 years, or 9%. The individual effect of postponement is substantially higher below age 16 than above, but at the aggregate level this is partially offset by the fact that for each additional year there are more individuals who are not biologically constrained: A universal constraint on marriages below 16 would increase average schooling by only 0.22 years. In addition to increasing education, later marriage is associated with significant improvements in utilization of prenatal care services. Since these gains are independent of schooling attainment, they indicate an important age effect of marrying late in addition to the potential impact of education on health behavior.

Our approach fills an important gap in the existing literature on marriage institutions in developing countries by generating possibly the first estimates of the causal effect of child marriage on female schooling and predicted impact of age of consent laws. While there is a small literature that investigates the correlates of marriage age, little research has examined the direct influence of early marriage, presumably due to the difficulty of finding exogenous variation in institutional rules. The methodology we introduce to predict equilibrium responses from reduced form estimates can potentially be used in other settings to assess the impact of imposing constraints on transactions in a competitive market.

2 Motivation

The gender gap in schooling attainment remains high in many parts of the developing world, even in settings in which the economic returns to schooling appear to be as large or larger for women than for men or the direct costs are lower (Schultz, 1987). For instance, in Bangladesh, only 56% of women between the ages of 25 and 30 in 1996 completed primary school (grade 5) relative to 77% of men in their cohort, and more than twice as many boys as girls enrolled in grade 10 (Bruce et al., 2001; Khandker and Samad, 1995). Particularly striking is the fact that even in recent years when the government of Bangladesh has provided a universal stipend for female secondary school that covers the bulk of the direct costs of education for girls but not boys, the attainment gap has persisted. Although girls and boys are now equally likely to *enroll* in secondary school, girls drop out by grade 11 (age 16) at five times the rate of boys.³

³ In particular, according to a recent project evaluation, female students constituted 48 percent in grades 6-10 but only 13 percent in grades 11-12 (Mahmud, 2003).

In settings such as Bangladesh, traditional customs that sanction adolescent marriage are frequently blamed for low female schooling attainment because they raise the opportunity cost of educating girls. As summarized in the abovementioned report, “the pressure for early marriage remains a powerful force that shapes the alternatives girls have and constrains their access to secondary education” (Mahmud, 2003). However, while it is true that child marriage and low female schooling attainment go hand in hand since girls rarely continue school once they are married, this by itself reveals little about the degree to which parents’ choices are constrained by marriage opportunities and hence the added schooling that girls would receive if the practice were abolished.

For a number of reasons, laws that encourage girls to postpone marriage may not improve their schooling outcomes or overall well-being. First, parents’ motives for marrying daughters at young ages are often strongly related to economic circumstances of the family. In addition to removing the economic burden on their parents’ household, younger brides typically attain higher status husbands with lower dowries. Hence, families who choose this path may be those that are unable to provide for their daughters or care least about their welfare. Higher education may further increase the price a girl has to pay for a spouse if social norms require that husbands have higher education levels than wives, giving further disincentive for parents to invest in daughters’ schooling before marriage. In contrast, a girl’s education is rarely valued in traditional marriage markets so would not directly improve her choice set. Second, delaying marriage might not increase girls’ education because of lack of schooling opportunities, in which case forcing girls to marry later might cause them to be sent into the labor force to provide for their families and cover the increased cost of marriage.

In what follows we focus on the question how age of consent laws would affect female education, and refrain from interpreting the results in a formal welfare analysis. This is mainly because the data available to us do not provide sufficient information for such an analysis. First of all, in most cases of adolescent marriage, the relevant decision makers are parents or caretakers and we cannot assess the extent to which they internalize the interests of their children. For example, if parents are not fully altruistic and marriage is costlier for girls who marry later, then girls end up marrying inefficiently early. Even if parents try to incorporate their daughters’ interests into marriage decisions, they might make systematic errors, for example underestimating the value of education. Second, it is difficult to quantify the positive

externalities of an increase in female education in Bangladesh. Third, if an age of consent law affects the level of dowries in the marriage market, then a welfare analysis would need to take into account the induced changes in household consumption.

3 Data and Methods

3.1 Setting

We examine the causal effect of adolescent marriage among a representative sample of women in Matlab, a relatively impoverished region of rural Bangladesh. The setting is appropriate given low levels of average schooling and marriage age. Nation-wide only about 70% of children in Bangladesh enroll in primary school, of which almost two-thirds drop out before completing the 5-6-year cycle. Bangladesh also has one of the lowest adult literacy rates in the world, averaging around 30% for adults over 40, and only 22% for women. In addition, early marriages are customary for female adolescents throughout rural Bangladesh, almost all of which are arranged by parents.⁴ The International Centre for Research on Women's Demographic Health Survey 1996–2001 lists Bangladesh as the country with the second-highest rate of child marriage, with an estimated 75 per cent of girls married before they reach age 18 (ICRW 2003). In response to the problem, the government has attempted on several occasions to institute age of consent laws, none of which have had a discernable effect on marriage practices in rural areas.⁵ While the country has witnessed a gradual increase in the average age of female marriage of approximately three years over the past quarter century, a significant fraction of girls continue to marry below the age of 16.⁶

An important feature of local marriage markets is the dowry system. Although dowries are currently illegal in Bangladesh, they are prevalent among Muslims and Hindu families alike. In the MHSS data, roughly two-thirds of recent brides (under age 30) report some amount of dowry given to their husbands' families at marriage. Dowry is typically under control of the woman's husband and in-laws, and it can be difficult for a woman to secure for her own use should the marriage terminate (Bates et al., 2004).

3.2 Data

⁴ In Matlab, only 1.6% of women under 44 report independently selecting their spouse (1996 MHSS data).

⁵ Arends-Kuening and Amin (2000) report that the series of child marriage acts in Bangladesh, which gradually increased the legal age of marriage from 12 to 18, had almost no effect on the timing of marriage for rural households other than to encourage misreporting on marriage documents.

⁶ An estimated 75 percent of rural girls in Bangladesh marry before the age of 16 (Barkat and Majid, 2003).

Data for the analysis come from the 1996 Matlab Health and Socioeconomic Survey (MHSS). The primary survey consists of household- and individual-level information on 4,364 households clustered in 2,687 baris, or residential compounds, an approximate one-third random sample of the total number of baris in the surveillance area (Rahman et al., 1999). The primary sampling unit of the MHSS was the bari, a cluster of extended families that functions as the basic unit of economic activity, landholding, and social identity. In each bari a maximum of two households were selected for interview. Within households, all individuals over 55, the head, spouse and parents of the head, and a random sample of other members between 15 and 49 were interviewed.

The MHSS data are ideal for implementing our identification strategy. First, detailed economic and demographic data were collected at the individual, household and village levels. In particular, each ever married woman was asked to provide complete schooling, marital and reproductive histories, including the timing of menarche, age at first marriage and outcome of all pregnancies. An important advantage of the data is the fact that survey reports of births and marriages could be cross-checked with vital statistics information including marriage and birth records from the regional Demographic Surveillance System (DSS), minimizing concern over recall bias and misreporting.⁷ All sample members were also asked about current health status and survey-takers collected anthropometric measures including height and weight on site. Information on family background was collected in a survey module pertaining to sample members' parents, and currently married women were asked about details of their married life and health behaviors.

3.3 Sample construction

We limit our sample to the 2,101 ever married women between the ages of 25 and 44 who have non-missing data for our outcomes of interest, excluding women in the Determinants of Natural Fertility Survey (DNFS) sub-sample. The left-hand cut-off point was chosen to minimize censoring of women who marry for the first time late in life while retaining the largest possible share of the sample. Of the women in our sample, 95.5% are currently married, 3.1% are unmarried widows, and 1.4% are unmarried divorcees.

⁷ Note that approximately 25% of sample members born outside of the region are absent from birth records and marriage records are missing for at least 5% who married prior to 1973.

Summary statistics for the sample are presented in Table 1, divided according to age of marriage and age of menarche. The data reflect the national patterns of low female marriage age, schooling and literacy, and high fertility. The median age of first marriage is 15, and the sample has extremely low levels of education and literacy. Among those who ever attended school, 41% cite marriage as the primary reason for dropping out. Roughly one third of the sample reports some form of subservience to their spouse or in-laws, as indicated by being prevented from leaving the house for work or family visits or having money or possessions taken from them, although the majority report participating in family decisions.

As reported in columns 2 and 3, differences in schooling outcomes between women who marry early and late are consistent with the global trends: The literacy rate among women who married before age 16 is only 60% that of women who marry later and schooling attainment is 1.3 years lower. The fact that father and mother's schooling and own school enrollment at age 9 are also significantly higher for women who marry later indicates important unobservable differences between these subsamples confounding OLS estimates of the relationship between marriage age and adult outcomes.

3.4 Estimation strategy

To assess the causal effect of early marriage on female schooling, we use age of menarche as an instrumental variable (IV) for marriage age. As demonstrated in numerous medical studies, the transition from childhood to reproductive age in normal, healthy adolescents occurs across a wide range of ages in any population (Scott et al., 1985; CEDG, 1998). In Bangladesh, where age at first marriage is traditionally bounded below by menarche, these differences generate exogenous variation in girls' risk of marrying young (Begum, 2003). Although informal pre-arrangements may be made when children are young, it is relatively rare to enter a girl into an official union before she has reached puberty.⁸ Meanwhile, menarche generates a strong shift in parents' demand to marry daughters. As explained by Begum (2003), "In Bangladeshi society a teenage daughter reaching menstruation becomes a burden for many parents because preservation of her virginity is the greatest concern for a bride. As a result ... parents like to get their daughters married as early as possible."

⁸ Bullough (1981) reports that "In Islamic countries it was criminal to have sexual relations with a woman before she had menstruated. Before a marriage ... women were to examine the girl to see that she was physically prepared."

For the most part, the MHSS data reflect these patterns. Columns 4-6 of Table 1 report the mean ages at first marriage corresponding to each year of menarche in the sample, also illustrated in Figure 1. Over 70% of first marriages take place within two years of menarche. Less than 18% of women report pre-pubescent marriages, and the majority (68%) of these cases are those in which marriage precedes menarche by 1 year. As evident in Figure 1, after age 13 the timing of first marriage climbs steadily with the onset of puberty. Figures 2a and 2b show the distributions of age of marriage and menarche, revealing a significant symmetric shift in the timing of marriage with each tercile of menarcheal age.

The IV approach involves estimating a two-stage model of the following form, where Y_i is the outcome of interest, A_i is individual i 's age at marriage, and Z_i is i 's age at menarche, the instrument used to identify the first-stage equation:

$$Y_i = \alpha_0 + \alpha_1 A_i + \alpha_2' X_i + \nu_i \quad [1]$$

$$A_i = \beta_0 + \beta_1 Z_i + \beta_2' X_i + \nu_i \quad [2]$$

In all of the estimates, X_i includes the following set of controls: adult height, family background and family composition characteristics, religion, and a dummy variable indicating whether the woman currently resides in a district of Matlab that is part of the treatment region for the national fertility intervention. Family background characteristics include: father and mother's education, whether father owned farmland or a family business, value of father's property, number of siblings, number of female siblings, whether mother and father survived to age 50, and whether the individual was enrolled in school at age nine. As detailed in Joshi (2003), economic circumstances of the family, including whether a girl's father was alive at marriage, are strong predictors of marriage market outcomes in the MHSS sample.⁹ We also include five-year age intervals, and a linear time trend for age.¹⁰ Robust standard errors are used in the analysis to correct for clustering at the bari level. The above set of equations in which Y_i is continuous implies a standard two-stage estimation procedure with continuous dependent and endogenous variables. For all binary outcomes, including literacy and school enrollment, the effect of marriage timing is estimated with the Amemiya Generalized Least Squares

⁹ Dummy indicators of whether parents were alive at marriage produce similar results to mortality by age 50, but are arguably less exogenous to marriage timing.

¹⁰ All estimates are also run with single year of birth fixed effects and dummy indicators of village of residence. The point estimates throughout are robust to this specification, although the Table 8 results lose statistical significance when both sets of fixed effects are included.

(AGLS) estimator for probits with endogenous regressors.¹¹

Identification of the IV model requires a strong correlation between age of menarche and age of first marriage. As the pattern in Figure 1 illustrates, this requirement is well satisfied in the MHSS data. Results from the first stage regression with and without the full set of controls and village fixed effects are presented in Table 2. For the base specification with full set of controls (column 3), every additional year that puberty is delayed, marriage is postponed an estimated 0.74 years, with a standard error of 0.06 and an F-statistic of 146. Column 2 allows for non-linearity in the effect of menarche on marriage by including dummy indicators of menarcheal age. Throughout the analysis, results are presented with the specification of column 3, but are universally robust to a non-linear first-stage and village fixed effects (column 6).

4 Estimation Issues

4.1 Endogenous instruments

In order to identify an IV model using age of menarche as an instrument for marriage timing, the exclusion restriction requires that the relationship between puberty and adult outcomes is fully mediated by changes in age at first marriage, such that delayed marriage is the only pathway through which physical maturation influences schooling. Biological research into the determinants of age of menarche reveals that genetic factors are by far the strongest predictors of adolescent development and that random genetic variation is a significant component of timing (Campbell et al., 1995). For instance, in one landmark study, Kaprio et al. (1995) compared the correlation in age of onset across 1,283 pairs of monozygotic and dizygotic twins and found that the correlation in age of onset among dizygotic twins was merely 0.21, while the correlation among monozygotic twins was nearly three times as large. These differences indicate a high degree of genetic determinism and hence a minimal role of environmental influences on maturation.¹²

¹¹ Newey (1987, eq. 5.6) provides the formula used. The endogenous regressors are treated as linear functions of the instruments and the other exogenous variables (Keshk, 2003; Maddalla, 1983). In Stata, this is implemented using the *divprob* command.

¹² The same study estimated that genetic factors explained 74% of variance in age at menarche, a finding that is consistent with many other estimates of heritability from human (Meyer et al., 1991; Gedda and Brenci, 1975; Fishbein; 1977; Sklad, 1977) and animal studies (Nelson et al., 1990).

While these patterns indicate a high degree of variation in timing of menarche that is unrelated to family background, there is nevertheless room for external influences on age of onset that may be particularly relevant in less developed countries. The following factors are known from laboratory experiments to have the potential to influence menarche: geography and climate (altitude and cold weather are thought to delay puberty; Nazian et al., 1976; Lehrer, 1986); strenuous physical activity or stress (ambiguous direction of influence, but in most cases causes delay; Pellerin-Massicotte et al., 1997; Bronson, 1997); exposure to endocrine-disrupting chemicals, including hormone-mimicking agents other toxic substances such as lead (direction of influence varies by compound; estrogen-mimicking compounds hasten onset while testosterone-mimicking compounds delay onset)¹³; sex composition of peer group (ambiguous direction; Vandenberg, 1969; Vandenberg et al., 1975; Mucignat-Caretta et al., 1995); and abrupt changes in diet resulting in acute malnutrition in utero or in childhood (delays onset).¹⁴

The first five factors are unlikely to confound our analysis. In the relatively small and uniformly rural district of Matlab, there is little variation in climate or altitude. Sex composition of peer group is arguably distributed across individuals independently of adult outcomes. While exposure to environmental pollutants such as lead and pesticides are strongly correlated with income in some settings, within Matlab chemical exposure is unlikely to confound the analysis, controlling for age. Similarly, while in many parts of the world hard labor is strongly associated with poverty, it is unlikely to vary within this population since very few adolescent girls engage in work outside of the residence.

In contrast, the potential correlation between menarche and nutrition is a concern in this sample: the rate of acute malnutrition in rural Bangladesh was 10.7% in 1999.¹⁵ The extent to which this poses a problem for our analysis depends on whether differences in nutrition are large enough to exert an influence on endocrine systems. Though a vast number of non-experimental studies suggest that age of menarche is potentially sensitive to moderate changes in nutritional intake, results from human studies are inconclusive due to

¹³ Whitten, 1993; Walters, 1993; Gellert, 1995; Kimmel et al, 1980; Komura et al, 1998; Der et al, 1974; Howdeshell et al, 1997; Stoker et al, 2000; Laws et al, 2000; Clark et al, 2000; Gray et al, 1995; Golub et al, 2004; Whitney et al, 2001; Yamada et al, 1989; Kramer et al, 1982; Cooper et al, 1997; Withuhn et al, 2003; Toppari et al, 1996; Andersson et al, 1999; Monosson et al, 1999; Gellert, 1978; McLachlan et al., 1977.

¹⁴ All laboratory evidence involves abrupt changes in food intake as opposed to chronic deprivation, so it is ambiguous whether such a shock is necessary to throw the hormone system off balance.

¹⁵ WHO Global Database (1999). See also Shahabudin et al. (2000).

the difficulty of isolating influences on puberty in non-experimental settings. A review of this literature and its shortcomings is detailed in Field (2007). As a result, laboratory experiments arguably provide the only reliable evidence on sources of interference.

While experiments show that food restriction has the potential to trigger delays in onset of puberty, this body of research reveals two important caveats. First, there is ample evidence that the influence of nutrition on hormone-releasing agents that trigger menses is only experienced at extremely high levels of food restriction. Among the laboratory studies investigating the correlation between food restriction and pubertal development reviewed as part of the Environmental Protection Agency's Endocrine Disrupter Screening Program (EDSP), only differences in food intake that reduced weight gain by more than 50% during developmental stages preceded and followed by abrupt return to normal levels of food intake resulted in delayed onset of puberty.¹⁶ More importantly, there is also significant evidence that any change in nutrition that has consequences for the timing of menarche would reveal itself in growth stunting. While no studies contained in the EDSP review in which food intake was manipulated to reduce body weight gain by 10 to 34% had any effect on menarche, stunting occurred at considerably lower levels of food restriction. Extensive animal studies from the 1910s and 1920s (see Krogman 135-137) also show consistently that malnutrition has a far bigger effect on growth in size than on maturational progress. Hence, while it is difficult to extrapolate observed dose responses to human populations, even a conservative interpretation of laboratory results indicate that only malnutrition severe enough to cause stunting during childhood could cause a delay in menarche, consistent with a recent assessment of human populations (Stathopulu et al., 2003). This fact allows us to assess the degree of endogeneity with data on the height of women in our sample. Adult height is commonly linked to early health status and nutrition. Since height is largely driven by prepubescent growth, it is widely considered to capture the degree of stunting due to inadequate nutrition and health in childhood.¹⁷

¹⁶ Engelbregt et al., 2002; Wilen et al., 1981; Dougherty et al., 1998; Friedman et al., 1990; I'Anson et al., 1991; Messer et al., 2000; Schneider et al., 1997; Vasallo et al., 1998; Wade et al., 1992; Aguilar et al., 1984; Merry et al., 1979; Ronnekleiv et al., 1978; Kennedy, 1963, 1957; Widdowson et al., 1960; Howenstein et al., 2000; Barash et al., 1996; Ahima et al., 1996, 1997; Plant et al., 1997; Cheung et al., 2001, 1997; Chehab et al., 1997; Mann et al., 2002. Summary table available at: <http://www.epa.gov/scipoly/oscpendo/pubs/edmvs/foodstudyreftable.pdf>.

¹⁷ A number of studies suggest the height of a child by age four is a discriminating indicator of previous nutrition and childhood disease, and a reasonably accurate predictor of adult height (Fogel, 1990, 1991; Herrinton and Husson, 2001; Martorell and Habicht, 1986; Martorell, 1993).

Table 1 presents summary statistics broken down by menarche age terciles for a number of adult outcomes available in the MHSS including height. If the claim is correct that under-nutrition severe enough to delay menarche will necessarily reveal itself in extreme stunting, the data indicate no significant association between nutrition and age of menarche in the population of girls who reach puberty in the restricted age range. In a regression of adult height on age of menarche the coefficient estimate is very close to zero and insignificant, evident in the height data in row 1 (columns 5-7) of Table 1. Figure 3 shows the kernel density estimate of adult height by terciles of menarcheal age, revealing that the population distributions and not just averages are remarkably similar across all subsamples.¹⁸ This evidence is also consistent with the results of a recent detailed health study conducted in four rural villages of Bangladesh which found no statistically significant differences in the prevalence of major health conditions among menstruating and non-menstruating girls below age 16 (Chowdury et al., 2000). Other family background characteristics reinforce the anthropometric evidence. None of the following measures appear to differ significantly by age of menarche: father's and mother's education, family wealth, and number of siblings (Table 1).¹⁹ Furthermore, there is no significant association between age of menarche and a range of indicators of adult health status (Table 1).

This set of evidence suggests that much of the variation in timing of first menstruation is uncorrelated with determinants of adult well-being other than marriage age, and that differences in family background according to age of menarche are unlikely to confound the analysis. Height can also be included as a right-hand-side variable in the regression analysis in order to control for early nutritional status. Because adult height may not be a sufficient statistic for childhood nutrition, we also control for other available indicators of childhood SES, listed in Section 3.3.

Perhaps most importantly, the potential association between age at menarche and early childhood nutritional status is substantially less of a concern due to the fact that low socio-economic status (SES) is universally associated with lower educational attainment. Hence, omitted variables related to childhood SES in Equation 2 would presumably bias downward our IV estimates of the casual effect of delayed marriage on education and

¹⁸ If anything, adult height appears to be slightly skewed to the left for girls who mature early, consistent with studies from development biology that show that reaching puberty early is associated with shorter stature in adulthood with no corresponding effects on health.

¹⁹ Nor is there an apparent difference in menarcheal age, controlling for height, by time trends in economic conditions. Statistical tests confirm the absence of a significant correlation between puberty and national GDP or average rainfall (gathered from the University of Delaware Air and Temperature Precipitation Data for years 1950-1996) during childhood. Estimates available from the authors upon request.

literacy (by biasing downward our first stage estimates of the effect of menarche on marriage). In addition, because endogeneity is an issue of central concern to the analytical methods, we limit the age range of menarche to 11 to 16 years in order to reduce the likelihood that maturation is correlated with family background. This range covers 90% of women in the sample. Both very early and very late first menstruation is linked to chronic medical conditions, as well as extreme physical and emotional stress (Palmert and Boeppel, 2001).

4.2 Selective mortality

Another estimation issue in using retrospective information is selective mortality. If either early marriage or early menarche is associated with higher mortality in adulthood, the estimates could be biased. For this reason, we restrict the sample to women under the age of 44. Data from the region indicates that selective mortality is unlikely to present a problem within this range: According to MHSS data on respondents' mothers, 82% of mothers born between 1935 and 1945 are alive in 1996. Although the statistic is not perfectly analogous to probability of dying between 15 and 43 since mothers are on average older than 15, life expectancy should be significantly higher for women in younger cohorts and at younger ages.²⁰

4.3 Recall bias

Another concern with the data is potential measurement error due to recall bias or systematic misreporting in the variables collected retrospectively. As mentioned earlier, the ability to double check birth and marriage data with DSS records eliminates much of the concern over measurement error in these data.²¹ In contrast, age of menarche is not possible to cross-check with outside sources as no records are kept of this event by government or health practitioners. Given this, one fear is that imperfect recall may lead respondents to approximate

²⁰ In addition, we restrict the sample to women between the ages of 26 and 44 since women over 43 in 1996 were unlikely to have any opportunity to attend secondary school. Due to extremely limited educational opportunities for girls in rural Bengal prior to 1962, less than a third of MHSS women over 43 were enrolled in school at age 9 and only 3.64% attended secondary school, implying that very few women remained in school long enough for matriculation to be effected by physical maturation. According to MHSS data, 75% of schools in the region were established after 1960. In 1960, there were only 4 secondary schools in Matlab, only one of which accepted girls. We choose the cut-off age for schooling opportunities to be consistent with the cut-off age in the regression analysis: when the first schools built during expansion opened in 1962, women born in 1953 would have been 9 years old, so we identify this cohort as the first group of women for whom secondary school was a real possibility.

²¹ Because a considerable fraction of women were either born outside of Matlab or are too old to have complete demographic records, we conduct separate analyses of older cohorts and in-migrants.

menarche with marriage such that the correlation is spuriously strengthened.

We do not expect measurement error to present a significant problem in these data for two reasons. First, recalled age of menarche has been shown to be highly reliable in numerous studies. According to a survey by Ellis (2003), “both adolescent girls and adult women are generally willing and able to report accurately on their ages at menarche ... and retrospective reports may be more reliable than those obtained during puberty (reviewed in Graber, Petersen, & Brooks-Gunn, 1996; see also Dorn, Nottelmann, et al., 1999).”²² Although women in Matlab are in many ways uncharacteristic of average respondents, special care was taken by MHSS survey-takers to collect accurate reproductive histories, including probing respondents with memory triggers and monitoring responses with a range of consistency checks (Rahman et al., 2000). Furthermore, since the DSS has operated for over 30 years in Matlab, residents are relatively accustomed to calculating and reporting ages associated with lifecycle events. Hence, it is reasonable to expect respondents to report menarche with equal accuracy.

Second, due to the social importance of this event in rural society, marked by many important and dramatic lifestyle changes, it is reasonable to expect that women remember the timing with even greater precision than women in developed countries. For example, as soon as a Muslim girl in Bangladesh reaches menstruation she is instructed to pray five times a day, to keep fast, to wear special clothes such as long shirts and trousers, and to cover her head and breast with a veil (Begum, 2003). According to a recent qualitative study of adolescents in Matlab, 100% of girls associate menarche with changes in dress, and 67% associate menarche with increased housework (Bosch, 2001). Additional research reports that the majority of girls are unaware of menstruation before it begins and as a result frequently terrified and traumatized by the event (Nahar et al., 1999). The religious beliefs associated with these practices in addition to observable physical changes that occur with puberty also decrease the possibility that families are willing and able to disguise menarche in an effort to reduce potential stigma associated with postponing wedlock. Furthermore, there is no anecdotal evidence that stigma of marrying late falls as puberty rises. If anything, families have strong economic incentive to reveal a daughter’s eligibility for marriage as soon as it is socially acceptable to do so.

²² As the article elaborates, “Test–retest reliability has been established in several long-term prospective studies in which self-reported age at menarche was first obtained in adolescence and then again 17 to 37 years later. Correlations across these two measurement periods have been consistently high, ranging from .67 to .79 (Casey et al., 1991; Damon et al., 1969; Livson & McNeill, 1962; Must et al., 2002).”

Finally, there is no empirical evidence of significant recall bias. For instance, many types of imperfect recall would show up in changes in the distribution of menarcheal age over time, yet the data reveal no significant heteroskedasticity with respect to menarche reports and respondents' age.²³ A more comprehensive diagnostic check involves comparing the distributions of menarche age between women with educated and uneducated mothers, reported in Figures 4a and 4b.²⁴ In particular, we separate mothers according to whether they were sent to school before age 10, which is presumably unrelated to maturation. Here, the idea is to isolate a group of families who have a pre-existing preference for later marriage unrelated to their daughter's maturation. Since menarche is exogenous to this preference, a significant difference in reported age-of-onset across these types would suggest either recall bias or strategic misreporting. Instead, as revealed in Figure 4a, while the first group has a significantly higher first marriage age and the distribution of marriage age is strongly shifted to the right, Figure 4b reveals no significant difference between the distributions of age-of-onset across the sub-samples.

4.4 Intergenerational effects

The genetic component of age of menarche may imply that women with later onset have the additional advantage of having mothers who also experienced later marriage. In this sense, the benefits of later marriage may be transmitted through intergenerational linkages other than biology. If late marriage leads to higher schooling attainment, families in which this biological trait is prevalent across generations may be those with persistently higher investment in girls.

While the data will not allow us to directly measure intergenerational correlations between age of menarche and marriage timing, we predict the influence of this indirect channel to be relatively minor for a number of reasons.²⁵ First, marriage timing has little potential influence on the schooling outcomes of older cohorts of women, for whom schooling opportunities were extremely scarce. Second, Table 1 means reveal that observable measures of

²³ Potential population changes over time in age of menarche limit the ability to perform standard diagnostic checks of additive measurement error with age. For instance, it is ambiguous whether the fact that average age of menarche rises slightly over time reflects a biological phenomenon or a relationship between recall bias and age.

²⁴ In particular, we separate mothers according to whether they were sent to school before the age of 10, which is presumably unrelated to maturation.

²⁵ An unfortunate disadvantage of these data is that the sample of ever-married women contains very few sibling or mother-daughter pairs due to the fact that, in rural areas of the country, married couples generally live in the husband's parents' household during the husband's fathers' lifetime.

family background are balanced by menarche age group. Finally, regression controls for available family background characteristics minimize the potential influence of second-order effects on the empirical estimates.

5 Results

5.1 Schooling and literacy

To gauge the impact of marriage timing on schooling attainment, we measure the impact of delayed marriage on highest grade attained and literacy rates among women who were enrolled in school at age 9.²⁶ We restrict the sample to those who were enrolled in school at age 9 in order to focus the analysis on girls for whom the marriage constraint is potentially binding. This amounts to isolating the treatment on the treated (TOT) as opposed to calculating the intent-to-treat effect, which provides valuable precision when close to half of the population is known to be outside the sphere of influence. Although earliest menarche is 11, we choose 9 as the cut-off point for school attendance since signs of menarche may appear up to two years before onset.

Results from the IV estimates for schooling and literacy are reported in Table 3 alongside corresponding OLS estimates. Columns 1-4 report grade attainment and literacy for women who were enrolled at 9. The results indicate that postponing marriage by one year between ages 11 and 16 increases educational attainment by an average of 0.22 years. Correspondingly, an additional year of delay increases adult literacy by 5.6% (4.1 percentage points). These estimates suggest that universal marriage postponement would generate substantial increases in educational attainment and literacy among those who have access to primary school, *ceteris paribus*. For instance, expanding this estimate by the number of postponed marriage years necessary to increase the average marriage age from 15 to the legal minimum of 18 implies a 14.2% increase in average female schooling and an almost identical change in female literacy. Columns 5-8 repeat this exercise for the full sample of women, including the roughly 50% who were never enrolled in school and 6% who either started school after 9 or dropped out of school before 9. Not surprisingly, the ITT estimates of marriage age on schooling among the full sample are much weaker in both the OLS or IV specifications. Just as we would expect, the estimated magnitude is roughly half the size when all girls are included, and the attainment results only significant at the 10% level.

²⁶ Literacy is defined broadly from respondents' reports of reading and writing ability on a scale of one to three. Respondents that reported either one or two on both measures were considered literate.

Columns 9 and 10 of Table 3 show results from a control experiment in which marriage age instrumented with menarcheal age is regressed on school enrollment at 8. Assuming parents cannot predict timing of puberty from girls' observable characteristics at 8, the positive and significant coefficient on marriage age in column 9 indicates the presence of unobservable determinants of both schooling and marriage age that bias OLS estimates upwards. Meanwhile, the IV estimate is close to zero and insignificant, suggesting that the instrument is not contaminated by the same unobservable correlates.

5.2 Direct effect of menarche on schooling

Menarche itself may be the barrier to schooling, in which case increasing legal age at marriage would not have the estimated effect on education. This violation of the IV exclusion restriction could arise if traditional rules governing female mobility prevented girls from attending school after first menstruation. As opposed to the case of marriage, the MHSS data reveal that puberty is not a universal constraint on school attendance: 75% of girls that are enrolled in school a year before menarche remain in school for at least two years and their average length of time in school post-menarche is 2.5 years. Still, it could be the case that all of the estimated schooling effect is attributable to a relaxation of the puberty constraint facing up to 25% of girls from traditional families.

To test whether menarche has a direct effect on schooling we examine variation in the magnitude of estimates across women facing different observable constraints on marriage timing based on sex-specific birth order, a characteristic that is exogenous to age of puberty. On account of the traditional preference for marrying daughters according to birth order, women with older female siblings should have less opportunity to respond to early maturation since they face additional constraints imposed by sibling marital status. Hence, if education is influenced by marriage opportunities rather than puberty itself, schooling responses to puberty should be larger on average among first-born girls and decline steadily with sex-specific birth order. In contrast, if the effect of puberty delay is driven solely by traditional attitudes towards school attendance, the effects should be independent of birth order. To test this, we restrict the sample to women with at least one female sibling (90% of the sample) and regress schooling attainment on age of menarche and age of menarche interacted with number of older female siblings and sex-specific

birth order.²⁷ Because number of female siblings may be correlated with other family characteristics, all regressions control for total female and male siblings.

Results from both specifications are presented in Table 4. The estimates indicate that the schooling attainment of younger daughters is significantly less sensitive to age of menarche than that of older daughters. Since elder and younger daughters are evenly distributed across traditional and non-traditional families conditional on sibship size, this indicates *within*-family differences in the effect of menarche on schooling which must therefore be independent of parents' preference to keep girls out of school when they reach puberty. A courser way of studying these relationships is to run the baseline regressions separately for eldest and younger daughters. Doing so reveals that, conditional on enrollment at 10, age of quitting school is sensitive to menarche *only* for eldest daughters. Unless traditional attitudes systematically apply only to eldest girls, this finding provides strong evidence that puberty does not *directly* cause girls to quit school. It is hard to imagine that any social norm grounded in religious beliefs would vary systematically according to birth order.

As a second check on whether our results are driven by a direct influence of menarche on school attendance, we divide the sample according to religious practices associated with reaching puberty. In particular, the vast majority of women in our sample (74% of the analysis sample) report currently wearing a headscarf both at home and outside the bari, a change in dress that is traditionally required beginning at the onset of puberty. By regressing drop out age on age of menarche separately in these two subsamples, we test whether the relationship between schooling and menarche is as strong among women who do not observe such practices. Indeed, a comparison between the estimated coefficient on age of menarche in columns 4 and 5 of Table 4 reveals that schooling attainment and onset of puberty are just as highly correlated among women who are substantially less observant of traditional gender norms. The estimated effect of menarche on schooling is virtually unchanged when the sample is restricted to the minority of women least likely to observe restrictions on dress and mobility associated with puberty.

Both findings are consistent with two additional pieces of evidence: First, in a recent qualitative study of adolescents' views about menarche in Matlab, 86 post-menarcheal adolescent girls were asked to list all lifestyle changes associated with menarche (Bosch, 2001). Although a wide range and number of changes were reported, school attendance was not

²⁷ Sex-specific birth order is defined as number of older female siblings divided by total number of female siblings.

mentioned. In contrast, 67% report that they started helping with daily chores. Second, MHSS respondents were asked the primary reason they quit school, and none cite puberty or menarche.

5.3 Secondary outcomes

5.3.1 Health care behavior

Both an increase in education and an increase in marriage age may have secondary effects on female outcomes. To explore this, we analyze MHSS data on health care practices during pregnancy, including the rate at which a woman seeks pre-natal care when she is pregnant, the average number of pre-natal visits, and whether she has ever received an anti-tetanus shot (ATS) while pregnant.²⁸ Although there is evidence from past research that many health behaviors are positively influenced by schooling, the effect of early marriage on preventive care may operate through channels other than education. In particular, girls who begin their reproductive cycle at younger ages may be more isolated or less empowered and as a result less likely to seek appropriate health care during pregnancy and childbirth. To make this conceptual distinction clear, we refer to behavioral changes related to marriage age but not education as “age effects.”

To empirically disentangle the effects of education from determinants of health care practices related to marriage age, we make use of the fact that the education effects of marriage timing are only experienced by the subpopulation of girls who were enrolled in primary school. In this manner, marriage age and schooling attainment can be separately identified by comparing sub-samples of women that were and were not enrolled in school at age 9. Only if the influence of marriage age is restricted to the former group could education gains be entirely responsible for behavior change. If the unschooled are also better off, age effects must play a role. Table 5 presents results from the IV analysis on both sub-samples. In all estimates, age of marriage is instrumented by age of menarche as in the previous regressions.

These estimates suggest that health care practices improve substantially with later marriage. Interestingly, the estimates reveal significant improvements in prenatal care not only among the educated but also among the subpopulation for whom schooling is unaffected by

²⁸ Variables constructed from averaging responses across all pregnancies from following survey questions asked about each of a woman’s pregnancies: (1) “During pregnancy [...] did you ever have a pregnancy check-up?” (2) “How many antenatal visits did you have during [] pregnancy?” (3) “When you were pregnant with [] were you given an injection in the arm to prevent the baby from getting tetanus, that is, convulsions after birth?”

marriage age, indicating that the increases in health care utilization do not operate exclusively through changes in schooling. A year of marriage delay is associated with an 8.6% increase in the likelihood of prenatal care during pregnancy for women who attended school and a 9.1% increase for woman who did not attend school. There is also an associated increase on the intensive margin: A year of marriage delay is associated with a 5.7% increase in the average number of antenatal visits for women who attended school and an 11.6% increase for woman who did not attend school, and the effect is only significant for the latter. There is also a strong estimated influence of marriage age on receiving anti-tetanus shots during pregnancy among girls who did (11%) and did not (8.5%) attend primary school.

The results indicate that, whereas educated women are encouraged to take up prenatal services as a result of marrying late, uneducated women are influenced by later marriage only in terms of switching from one to several clinic visits. One interpretation of this pattern is that secondary school improves women's awareness of available health services, thereby increasing the likelihood that they will seek out any care. Meanwhile, marriage age alone increases the likelihood that a woman will have the freedom to take advantage of services known to her, for instance, by responding to health workers' suggestions for more frequent check-ups. For instance, uneducated women who marry later may have greater freedom to leave the home for or spend money on health care services. Consistent with this story, results from regressions of two indicators of personal freedom on marriage age indicate that unschooled women who marry later face fewer restrictions by husbands and in-laws with respect to consumption and mobility (columns 7 and 8). The dependent variable in these regressions is constructed from the following MHSS survey questions: whether respondent reports that husband or in-laws have ever prevented her from leaving the bari for work or family visits, or have taken away her money or possessions. Separate analysis on each of the four components reveals that the largest change comes from reducing the likelihood that women are prevented from leaving the bari for work. Since marriage age is not associated with a reduction in household restrictions among educated girls, there is no evidence that it operates through schooling. More likely, the effect is related to convergence in age between spouses that accompanies later marriage.

5.3.2 Spousal quality

The last stage of analysis examines trade-offs parents face in making decisions about

marriage timing by looking at data on dowry payments at marriage and observable characteristics of spouses. The finding that marriage opportunities curtail schooling investment suggests that the benefits to girls of delaying marriage come at a cost to their families, presumably in terms of higher dowry payments or less desirable spouses. Anecdotally, in rural Bangladesh dowries increase with each additional year that marriage is postponed because of the high demand for youthful brides.²⁹ Meanwhile, past findings from India confirm a strong positive association between dowry payments and suitability of the husband, measured in terms of his relative superiority in education and family socio-economic status (Halli, 2003).

To explore how parents respond to these trade-offs, we estimate the dowry cost of later marriages using the same IV strategy from the previous section. We similarly explore how characteristics of spouses in terms of education level, age, and family wealth are related to marriage timing. If parents indeed spend more on daughters who marry later, we can assess based on the distribution of husbands' observable characteristics whether the additional expenditure on later marriages is sufficient to buy their daughters positions in families of comparable quality to those of younger brides.

These estimates are presented in Table 6. Indeed, examination of the MHSS data suggests that the increased schooling accompanying late marriage comes at a substantial cost to the family. An IV estimate of the dowry cost of later marriages, presented in column 1, indicates that the wealth a girl brings into marriage increases by an average of 11% with each additional year that marriage is postponed, although the point estimate is only significant at the 10% level. Meanwhile, columns 2-5 reveal no corresponding improvements in the characteristics of spouses in terms of education level, age, or family background (father's education and wealth relative to bride's father). This combination of marriage market outcomes indicates that the average additional dowry cost of late marriage is a good approximation of the decrease in female marriage market value that accompanies age in rural Bangladesh. The fact that late-bloomers are no worse off in terms of observable spousal quality also potentially suggests a preference among parents for allocating marriage payments across daughters to equate their marital outcomes.

²⁹ Cited reasons for this preference include the beliefs that younger brides are (a) more fertile, (b) more likely to lack sexual experience, and (c) easier for husbands and in-laws to control. Foster and Kahn (2000) argue that the increase in female age at marriage and corresponding reduction in average age differences between spouses as an equilibrating mechanism for demographic changes in the supply of spouses reflects a decrease in the demand for youth in the marriage market.

6 General equilibrium analysis

The previous empirical estimates address how a woman's educational choice changes if her individual constraint, age of menarche, changes. This corresponds to asking how the chosen level of education changes when varying an individual's constraint *within the same equilibrium* of the marriage market. Hence, it is not immediately obvious how this estimate corresponds to the overall impact of imposing a universal constraint, which leads the market to a new equilibrium. In this section we analyze the general equilibrium effects of such a regulation, and use the results to estimate the impact of enforcing different possible legal ages of consent on female education.

6.1 Theoretical considerations

Here we provide a discussion of how the demand and supply of brides of different age levels are affected by imposing a minimum marriage age on the market. For a formal analysis, see Appendix B.

We think about the marriage market in Bangladesh as a large and impersonal market, where the demand and supply of brides and grooms are equated through dowry payments (payments from the bride's family to the groom). These payments depend on both the groom's and the bride's observable characteristics. The characteristic we focus on is the bride's age: we assume that there is a different market dowry level for every possible bride age. It is well-documented that men in Bangladesh have a preference for younger wives, and dowry payments are monotonically increasing in the bride's age. This creates an incentive for families to marry their daughters earlier, since this decreases the dowry payment they are required to pay. Nevertheless, women are heterogeneous in what age they decide to get married, partly because some women have exogenous restrictions on marriage age (for example because they reach puberty at an older age), and partly because some families decide to delay marriage despite the increased cost (for example to let the daughter to finish secondary school). In equilibrium, subject to the constraint imposed on marriage age by the age of puberty, we expect women who are more keen to marry early (or less keen to marry later) to enter the marriage market at a young age, marry men who are more eager to marry younger brides, and pay smaller levels of dowry. Similarly, we expect women who are more eager to marry later to enter the marriage market at

an older age, marry men who are less eager to marry younger brides, and pay higher levels of dowry.

Enforcing a minimal legal marriage age \bar{t} implies that women who in the absence of the regulation would have married younger than age \bar{t} must decide whether they still want to marry, and if yes then at what age satisfying the legal requirement. Similarly, men who in the absence of regulation would have married a bride younger than \bar{t} have to decide whether they still want to marry, and if yes then choose an optimal bride age among those that are legally permitted. In general, both the demand and supply of brides older than \bar{t} increase as a consequence of the regulation. However, in the absence of any restriction on preferences, there is no reason to expect a symmetric increase in demand and supply of all marriage ages older than \bar{t} . Hence, the prices (dowry levels) that cleared the market in the absence of regulation generally do not equilibrate the market after the regulation. To restore equilibrium, dowry levels corresponding to bride ages above \bar{t} must change. These price changes in turn can change the marriage age decisions of even those women who in the absence of regulation would have married later than \bar{t} , and can change the bride age choices of those men who in the absence of regulation would have chosen a bride older than \bar{t} . Hence, marriage age decisions are effected even for those people who are not *directly* affected by the regulation.

To illustrate the previous point, consider an example in which there are two types of women, w_1 and w_2 , and two types of men, m_1 and m_2 . Assume that the number of women is equal to the number of men, and that half of the women and men belong to each of the types above. There are three possible marriage ages of women: “very young”, “young”, and “mature”. Both women and men have quasilinear preferences in money. Men of type m_1 are more eager to acquire younger brides, and the utility they attain from marrying a very young, young, or mature bride is 150, 100, and 50 monetary units, respectively. Men of type m_2 attach utility levels 30, 20, and 10 for marrying a very young, young, or mature bride. In this example, assume that women reach puberty at a very young age and hence all women are free to choose among all possible marriage ages. Women of type w_1 are indifferent between marrying at a young or at a very young age, both giving them a utility of 20 monetary units, but they prefer to marry at a mature age, yielding a utility of 50 monetary units. For women of type w_2 , getting married at a

very young age gives a utility of 20 monetary units, getting married at a young age gives 40 monetary units, while getting married at a mature age gives 60 monetary units.

In this example, it is easy to verify that in any market equilibrium without regulation, women of type w_2 get married at a very young age (marrying men of type m_1), while women of type w_1 get married at a mature age (marrying men of type m_2), and they have to pay a dowry that is higher than what the other type of women pay by something between 30 and 40 monetary units (there is an indeterminacy in the market clearing price due to the finite number of types). At this dowry premium level, women of type w_1 are willing to pay the higher dowry and wait to marry until reaching a mature age, while women of type w_2 would rather marry at a very young age and save on the dowry payment.

Suppose now that an age of consent law is imposed on the market, banning marriage at a “very young” age. It can be shown that in any market equilibrium women of type w_2 (who absent of the regulation would have married at a mature age) marry at a young age (to men of type m_1), while women of type w_1 (who previously would have married at a very young age) marry at a mature age (to men of type m_2), and the market-clearing dowry premium for marrying at a mature age versus at a young age can be anything between 20 and 30 monetary units. Hence, the regulation imposed on the market switches the marriage order of different types of women.

The main feature of the above example is that women of type w_1 attain more utility from postponing marriage from a very young age to a young age than women of type w_2 , while the relative order of utility gains is exactly the opposite when postponing marriage from young to mature age. In the Appendix we formally show that if the relative order of incremental utilities from postponing marriage by a year remains the same over different age levels for any two women, and similarly the relative order of incremental utilities from marrying a one year younger bride remain the same over the whole range of possible bride ages for any two men, then imposing a minimal legal marriage age does not change the marrying order of different women and men.³⁰ In particular, if preferences satisfy this condition, then imposing a minimum legal age of marriage x induces a very simple equilibrium adjustment: women who in the absence of regulation would have married younger marry exactly at the new minimum legal age, while the marriage timing decisions of all other women remain unchanged. Moreover, the

³⁰ This restriction on preferences is similar to supermodularity assumptions often imposed in the matching and search literature (see, for example Shimer and Smith (2000) and Legros and Newman (2002)).

relative dowry premium for any additional year above x remains the same as before – that is, relative equilibrium prices are not affected by the regulation.

The meaning and validity of the above assumptions depend on the reasons behind preferences over female marriage age. Consider first that the main motivation for preferring younger brides is to increase fertility by expanding the reproductive interval.³¹ Then the above restrictions are equivalent to assuming that, (i) if for a man the incremental utility of the k th child is higher than for another man, then the same relationship holds between incremental utilities of the l th child as well, for any $k, l > 0$; and (ii) there is a similar stable ordering with respect to women's incremental utilities/disutilities from having an additional child. If degree of spousal control rather than fertility drives preferences over bride's age, then the restriction is equivalent to assuming that if an increase in spousal control gives higher utility to one man relative to another at some level of control, then the same relationship holds at every level. Finally, if women's age of marriage choices are mainly driven by schooling, then the restriction implies that the order of women concerning incremental utilities from additional years of schooling does not depend on which school year is considered. One characteristic of the setting that makes this assumption more appealing is that degree completion is uncommon within the age period under study. Since secondary school starts around age 12 and ends around age 18, the additional years of schooling we examine are additional years of high school for the majority of our sample.

The fact that the adjustment from one equilibrium to another is so simple, provided that the above assumptions hold for preferences of women and men, implies that our estimates of how a woman's education level depends on what age she reaches puberty can be used in a straightforward way to assess the impact of imposing various possible minimum legal ages for marriage on aggregate female educational attainment.

6.2 The effect of a minimum legal age of marriage on women's education

If equilibrium adjustment after imposing a minimum legal age of marriage \bar{t} simply implies that women who would have married at a younger age marry at the new legal minimum age, and that marriage time decisions of all other women are unaffected, then the following hold for how the educational attainment of different women are affected by the legal change: (i) there

³¹ While this is unlikely to be true given that fertility levels are nowhere near the biological maximum and very early childbearing can actually decrease future fertility, anecdotal evidence from many sources indicates that it is widely believed.

is no effect on women who reach puberty after age \bar{t} ; (ii) for a woman who reaches puberty before age \bar{t} , the introduction a minimum legal marriage age has the same effect as postponing her menarche to age \bar{t} . The introduction of a minimum marriage age imposes exactly the same lower bound on a woman's marriage age as if menarche was delayed, and since dowry premium levels above the minimum age do not change after imposing a legal minimum age, optimal choices adjust in the same manner. Then if age of menarche is distributed among women independently of their preferences, a reduced form estimate of the influence of delay in age of menarche on educational attainment can be used to provide an estimate of the average change in female education that arises from introducing distinct minimal legal ages of marriage. In particular, the effect on average female education of introducing minimal marriage age $\bar{t} > t_{\min}$ is:

$$\Delta \bar{E}_{\bar{t}} = \sum_{t=t_{\min}}^{\bar{t}-1} g(t) D_{t,\bar{t}}, \quad [6.1]$$

where g is the distribution function of menarche and $D_{t,\bar{t}}$ is the average effect of postponing the age of menarche from t to \bar{t} on years of schooling. This result enables us to provide a structural estimate of the impact of age of consent laws. In particular, the $D_{i,j}$ terms can be recovered from an OLS regression of schooling attainment on age of menarche, in which each menarcheal age is entered separately as a binary variable in the regression. Then [6.1] can be calculated for each possible $t_{\min} < \bar{t}$ using information from the MHSS sample on the distribution of age of onset.

For the policy predictions we restrict the sample to women who were enrolled in school at age 9, under the presumption that future cohorts will have near universal enrollment at early ages. According to these estimates, presented in Table 7, imposing a minimum marriage age of 14 would increase the average education of girls in Matlab by an average of only 0.07 years, while a legal minimum of 16 would increase average schooling by 0.376 years, holding the local supply of schools constant. The marginal effect of an age minimum is increasing through age 16, then falls thereafter.

To understand the determinants of this marginal effect, it is useful to rewrite [6.1] the following way:

$$\Delta \bar{E}_t = \sum_{t=t_{\min}}^{\bar{t}-1} \left(\sum_{k=t_{\min}}^{t-1} g(k) \right) D_{t,t+1}, \quad [6.2]$$

This formula reveals that the aggregate effect of increasing the minimum age depends on two factors: the number of women for whom it introduces a new constraint, and the extent to which it affects the schooling choices of these women. As we saw in Section 5, $D_{t,t+1}$, the incremental effect of an additional unmarried year for those who are affected by this change (the “treated” in the IV estimate) is substantial until age 16 and then significantly lower. However, this is partially offset by the fact that the number of women affected by the change, $\sum_{k=t_{\min}}^{t-1} g(k)$, is monotonically increasing. The higher the minimum legal age, the larger is the number of women who reach puberty by that age. In particular a substantial proportion of women reach puberty at age 16, increasing the marginal effect of setting the minimum legal age to 17 as opposed to 16.

Nevertheless, the marginal effect of increasing the legal age is decreasing after age 16. According to our estimates, minimum age laws of 16 would generate two-thirds of the schooling effects of minimum age laws of 17. This result has potentially important policy implications given the current predominance of high minimum marriage ages that appear to be too costly to enforce. A minimum marriage age of 16 would likely be far easier to enforce than the current target of 18 and still achieve most of the benefits in terms of female education.

7 Conclusions

This paper provides empirical evidence that the institution of adolescent marriage in developing countries reduces female education. When individual girls in rural Bangladesh are forced by biology to delay marriage, they attain significantly more schooling and are more likely to be literate. Under plausible assumptions about local marriage markets these results indicate a 5-8% improvement in average female schooling from enforcing consent laws from ages 15-16.

The approach we introduce to estimate equilibrium adjustment effects from partial equilibrium results can potentially be used in other competitive market settings to assess the impact of imposing lower bounds on transactions. One could for example examine the effect of imposing minimum quality standards for a given product of heterogeneous quality. Our methodology would identify conditions under which exogenous individual-level variation in marginal cost of product quality can be used to assess the impact of a universal quality regulation.

8 References

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APPENDIX

A1. The model

We consider a marriage market with a set of women $W = \{w_1, \dots, w_{n_w}\}$ and men $M = \{m_1, \dots, m_{n_m}\}$. The model is static in that all individuals enter the marriage market at the same time, however the same model can be derived from a dynamic model in which different cohorts enter the market each year.³² Therefore the static model can be viewed as a simplification that provides a shortcut for the analysis. In the model, women choose levels of schooling and age of marriage, and men choose the age of their brides. Both men and women have the option not to marry. For simplicity, men's schooling decisions are assumed to be independent of marriage market outcomes and therefore excluded from the analysis. Similarly, we assume that women do not care about the age of their spouses and do not explicitly model men's decisions concerning what age to marry. Note that although we talk about decisions of women and men in the marriage market, what we have in mind are the preferences and choices of the relevant decision makers such as parents.

Women can marry at ages $t_{\min}, t_{\min} + 1, \dots, t_{\max}$. Let x_i denote the marriage age decision of $w_i \in W$ and let y_i denote the decision of $m_i \in M$ on the age of his bride. For notational simplicity define x_i (similarly y_i) to be $t_{\max} + 1$ in the case that the individual decides not to marry. Women are constrained in their marriage age decision by age of puberty: $x_i \geq p_i$ where p_i is the age when $w_i \in W$ reaches puberty. With respect to schooling choices, let e_i denote the years of education above t_{\min} woman w_i chooses. An important assumption in the model is that women's education levels are constrained by marriage. In particular if woman w_i decides to marry at age t then $e_i \leq t - t_{\min}$.

We assume that the market is competitive, and that the market-clearing prices are dowries women pay to grooms at marriage that depend only on bride's age. Let $d(t)$ denote the amount of dowry a woman has to pay if decides to marry at age t . A woman who does not get married

³² See an earlier version of our paper.

does not have to pay any dowry: $d(t_{\max} + 1) = 0$. Individuals' preferences are assumed to be quasilinear in the amount of dowry paid or received.

The utility of woman w_i from marriage net of transfers is $u_i(x_i, e_i)$. Given that we assume that dowry depends on x_i but not e_i , we can simplify the utility function of women by substituting in the optimal level of education compatible with any given possible marriage time. Let $U_i(x) = \max_{0 \leq e \leq x - t_{\min}} u_i(x, e)$ for $x \in (t_{\min}, \dots, t_{\max})$ and $U_i(t_{\max} + 1) = \max_{0 \leq e} u_i(t_{\max} + 1, e)$ (women who do not marry do not face any constraint on education). We assume that U_i is concave but put no restriction on whether it is increasing or decreasing. The utility of man m_i from marriage net of transfers is $V_i(y_i)$.³³ We assume that V_i is decreasing and concave, which implies that dowries have to be increasing in bride's age in order to clear the market.³⁴

A.2 Competitive equilibria with and without minimum legal age of marriage

We define competitive equilibrium in the marriage market the standard way.

Definition: A competitive equilibrium of the marriage market consists of a vector of dowries $\hat{d}(t_{\min}), \dots, \hat{d}(t_{\max})$ and marriage age decisions $\hat{x}_1, \dots, \hat{x}_{n_m}, \hat{y}_1, \dots, \hat{y}_{n_w}$ such that $\hat{x}_i \geq p_i \quad \forall w_i \in W$ and the following conditions hold:

(i) Given the vector of dowries all men make an optimal choice and all women make a constrained optimal choice given that they can only marry after reaching puberty:

$$U_i(\hat{x}_i) - \hat{d}(\hat{x}_i) \geq U_i(x_i) - \hat{d}(x) \quad \forall p_i \leq x \leq t_{\max} + 1 \text{ and } w_i \in W$$

$$V_i(\hat{y}_i) + \hat{d}(\hat{y}_i) \geq V_i(x) + \hat{d}(x) \quad \forall t_{\min} \leq x \leq t_{\max} + 1 \text{ and } m_i \in M$$

(ii) The market clears for every possible marriage age:

$$\#\{w_i \in W : \hat{x}_i = x\} = \#\{m_i \in M : \hat{y}_i = x\} \quad \forall t_{\min} \leq x \leq t_{\max}$$

³³ In particular the utility of a man who decides not to get married is $V_i(t_{\max} + 1)$.

³⁴ Note that the model assumes that all women and men are of equal quality, in particular any man is indifferent between marrying two brides of the same age. This assumption is made to keep the model simple. Our conclusions would remain the same if parallel marriage markets existed for different quality women and men.

We also consider markets in which there is a minimum legal marriage age \bar{t} such that $t_{\min} < \bar{t} \leq t_{\max}$. In this case dowries are only specified for marriage ages \bar{t}, \dots, t_{\max} . A competitive equilibrium of the constrained market is defined analogously to the unconstrained market case.

In general it is difficult to relate equilibrium marriage age choices in the unconstrained market to a market with an age minimum. In what follows, we impose the assumption that both women and men can be unambiguously ordered with respect to their incremental utilities from delaying marriage by one year. We also make an assumption that rules out nongeneric cases in which there exist a woman and man for whom increasing the bride's age at marriage by one year gives them exactly the opposite incremental utilities. The latter assumption is needed to guarantee uniqueness of equilibrium, which facilitates the comparison of unrestricted and restricted markets.

A1: For any $w_i, w_{i'} \in W$ ($i \neq i'$) it holds that if $U_i(x) - U_i(x+1) \geq U_{i'}(x) - U_{i'}(x+1)$ for some $t_{\min} \leq x \leq t_{\max}$ then $U_i(x') - U_i(x'+1) > U_{i'}(x') - U_{i'}(x'+1) \quad \forall \quad t_{\min} \leq x' \leq t_{\max} - 1$.

A2: For any $m_i, m_{i'} \in M$ ($i \neq i'$) it holds that if $V_i(x) - V_i(x+1) \geq V_{i'}(x) - V_{i'}(x+1)$ for some $t_{\min} \leq x \leq t_{\max}$ then $V_i(x') - V_i(x'+1) > V_{i'}(x') - V_{i'}(x'+1) \quad \forall \quad t_{\min} \leq x' \leq t_{\max}$.

A3: For every $x \in \{t_{\min}, \dots, t_{\max}\}$ it holds that there are no $w_i \in W$ and $m_j \in M$ such that $U_i(x) - U_i(x+1) = -(V_j(x) - V_j(x+1))$

Theorem 1: Assume A1-A3 hold. Then there exists a unique vector of marriage time choices $\hat{x}_1, \dots, \hat{x}_{n_m}, \hat{y}_1, \dots, \hat{y}_{n_w}$ that can be part of a competitive equilibrium. Similarly, for every minimal legal marriage age $\bar{t} \in \{t_{\min} + 1, \dots, t_{\max}\}$ there exists a unique vector of marriage choices $\hat{x}^{\bar{t}}_1, \dots, \hat{x}^{\bar{t}}_{n_m}, \hat{y}^{\bar{t}}_1, \dots, \hat{y}^{\bar{t}}_{n_w}$ that can be part of a competitive equilibrium of the corresponding constrained market.

Proof: Before proving the theorem, we establish the following two lemmas.

Lemma 1: Assume A1 and A2 hold. If $\hat{d}(t_{\min}), \dots, \hat{d}(t_{\max}), \hat{x}_1, \dots, \hat{x}_{n_w}, \hat{y}_1, \dots, \hat{y}_{n_m}$ is a competitive equilibrium then for every $x, x' \in \{t_{\min}, \dots, t_{\max} + 1\}$ such that $x' > x$ the following properties hold:

$$\#\{w_i \in W : \hat{x}_i = x'\} \neq 0 \text{ implies } U_i(x') - U_i(x) \leq \hat{d}(x') - \hat{d}(x) \quad \forall \quad w_i \in W \text{ st } \hat{x}_i \leq x,$$

$\#\{m_i \in M : \hat{y}_i = x'\} \neq 0$ implies $V_i(x) - V_i(x') \geq \hat{d}(x') - \hat{d}(x) \quad \forall m_i \in M$ st $\hat{y}_i \leq x$,
 $\#\{w_i \in W : \hat{x}_i = x\} \neq 0$ implies $U_i(x') - U_i(x) \geq \hat{d}(x') - \hat{d}(x) \quad \forall w_i \in W$ st $\hat{x}_i \geq x'$
and $p_i \leq x'$,

$\#\{m_i \in M : \hat{y}_i = x\} \neq 0$ implies $V_i(x) - V_i(x') \leq \hat{d}(x') - \hat{d}(x) \quad \forall m_i \in M$ st $\hat{y}_i \geq x'$.

Proof : Suppose the claim does not hold. Consider first the case that $\exists m_i \in M$ and $x, x' \in \{t_{\min}, \dots, t_{\max} + 1\}$ such that $\hat{y}_i \leq x$, $x < x'$, $\#\{m_j \in M : \hat{y}_j = x\} \neq 0$ and $V_i(x) - V_i(x') < \hat{d}(x') - \hat{d}(x)$. If $\hat{y}_i = x$, then the previous inequality directly implies that \hat{y}_i cannot be an optimal choice for m_i , a contradiction. Suppose now that $\hat{y}_i < x$. Since $\#\{m_j \in M : \hat{y}_j = x\} \neq 0$, $\exists m_{i'} \in M$ such that $\hat{y}_{i'} = x$. Since $\hat{y}_{i'} = x$ and $\hat{y}_i < x$, it has to be that $V_{i'}(\hat{y}_i) - V_{i'}(x) \leq V_i(\hat{y}_i) - V_i(x)$. Then A1 implies that $V_{i'}(x) - V_{i'}(x') \leq V_i(x) - V_i(x')$, which further implies that $V_{i'}(x) - V_{i'}(x') < \hat{d}(x') - \hat{d}(x)$, contradicting that $\hat{y}_{i'} = x$ is an optimal choice for $m_{i'}$. Consider next the case that $\exists m_i \in M$ and $x, x' \in \{t_{\min}, \dots, t_{\max} + 1\}$ such that $\hat{y}_i \geq x'$, $x < x'$, $\#\{m_j \in M : \hat{y}_j = x'\} \neq 0$ and $V_i(x) - V_i(x') > \hat{d}(x') - \hat{d}(x)$. If $\hat{y}_i = x'$, then the previous inequality directly implies that \hat{y}_i cannot be an optimal choice for m_i , a contradiction. Suppose now that $\hat{y}_i > x'$. Since $\#\{m_j \in M : \hat{y}_j = x'\} \neq 0$, $\exists m_{i'} \in M$ such that $\hat{y}_{i'} = x'$. Since $\hat{y}_{i'} = x'$ and $\hat{y}_i > x'$, it has to be that $V_{i'}(x') - V_{i'}(\hat{y}_i) \geq V_i(x') - V_i(\hat{y}_i)$. Then A1 implies that $V_{i'}(x) - V_{i'}(x') \geq V_i(x) - V_i(x')$, which further implies that $V_{i'}(x) - V_{i'}(x') > \hat{d}(x') - \hat{d}(x)$, contradicting that $\hat{y}_{i'} = x'$ is an optimal choice for i' . Proving that the corresponding claims for women is analogous to the above, using assumption A1. QED

Lemma 2: Assume A1 and A2 hold and there is a minimum legal age of marriage $\bar{t} \in \{t_{\min} + 1, \dots, t_{\max} - 1\}$. If $\hat{d}(\bar{t}), \dots, \hat{d}(t_{\max})$, $\hat{x}_1, \dots, \hat{x}_{n_w}$, $\hat{y}_1, \dots, \hat{y}_{n_m}$ is a competitive equilibrium then for every $x, x' \in \{\bar{t}, \dots, t_{\max}\}$ such that $x' > x$ and $\#\{w_i \in W : \hat{x}_i = x'\} \neq 0$ the following hold:

$$U_i(x) - U_i(x') \leq \hat{d}(x') - \hat{d}(x) \quad \forall w_i \in W \text{ st } \hat{x}_i \leq x$$

$$V_i(x') - V_i(x) \geq \hat{d}(x') - \hat{d}(x) \quad \forall m_i \in M \text{ st } \hat{y}_i \leq x$$

Furthermore, for every $x, x' \in \{\bar{x}, \dots, t_{\max}\}$ such that $x' > x$ and $\#\{j \in W : \hat{x}_j = x\} \neq 0$ the following hold:

$$U_i(x) - U_i(x') \geq \hat{d}(x') - \hat{d}(x) \quad \forall w_i \in W \text{ st } \hat{x}_i \geq x' \text{ and } m_i \leq x'$$

$$V_i(x') - V_i(x) \leq \hat{d}(x') - \hat{d}(x) \quad \forall m_i \in M \text{ st } \hat{y}_i \geq x' \text{ and } m_i \leq x'$$

Proof : Analogous to the proof of Lemma 1.

Proof of Theorem 1: Standard arguments establish the existence of competitive equilibrium. Suppose that the assumptions of the theorem hold and let $\widehat{d}(\bar{t}), \dots, \widehat{d}(t_{\max}), \widehat{x}_1, \dots, \widehat{x}_{n_w}, \widehat{y}_1, \dots, \widehat{y}_{n_m}$ and $\widehat{d}(\bar{t}), \dots, \widehat{d}(t_{\max}), \widehat{x}_1, \dots, \widehat{x}_{n_w}, \widehat{y}_1, \dots, \widehat{y}_{n_m}$ be two competitive equilibria of the marriage market with minimum marriage age $\bar{t} \in \{t_{\min}, \dots, t_{\max}\}$, where $\bar{t} = t_{\min}$ refers to the unrestricted market.

Reindex women and men such that $U_i(x) - U_i(x') > U_{i'}(x) - U_{i'}(x')$ and $V_i(x) - V_i(x') < V_{i'}(x) - V_{i'}(x')$ whenever $i' < i$ and $x < x'$. Assumptions A1 and A2 imply that there is a reindexing like that. Then we claim that if $x_1, \dots, x_{n_w}, y_1, \dots, y_{n_m}$ constitutes a competitive equilibrium with some dowry vector then $i' < i$ implies $y_{i'} \leq y_i$, and $i' < i$ and $p_{i'} \leq x_i$ imply $x_{i'} \leq x_i$. To see this, note that $y_{i'} > y_i$ for $i' < i$ contradicts that both $x_{i'}$ and x_i are optimal choices under the same dowry vector. Similarly, $x_{i'} > x_i$ and $x_i \geq p_{i'}$ for $i' < i$ contradict that both $x_{i'}$ and x_i are optimal choices under the same dowry vector.

Suppose now that $\widehat{x}_i = \widehat{y}_j$ and $\widehat{x}_i > \widehat{y}_j$. The above results then imply that $\widehat{y}_j < p_i$ and that $\exists i' > i$ such that $\widehat{x}_{i'} > \widehat{y}_j$ and $\widehat{x}_{i'} = \widehat{y}_j$. Then $\widehat{d}(\widehat{x}_{i'}) - \widehat{d}(\widehat{y}_j) \leq U_{i'}(\widehat{y}_j) - U_{i'}(\widehat{x}_{i'})$. By Lemma 1 this implies $\widehat{d}(\widehat{y}_j) - \widehat{d}(\widehat{y}_j) \leq U_{i'}(\widehat{y}_j) - U_{i'}(\widehat{y}_j)$. Furthermore, since \widehat{y}_j is an optimal choice for m_j given $\widehat{d}(\bar{t}), \dots, \widehat{d}(t_{\max})$, $\widehat{d}(\widehat{y}_j) - \widehat{d}(\widehat{y}_j) \geq V_j(\widehat{y}_j) - V_j(\widehat{y}_j)$. Combining the previous inequalities implies $V_j(\widehat{y}_j) - V_j(\widehat{y}_j) \leq U_{i'}(\widehat{y}_j) - U_{i'}(\widehat{y}_j)$. This can only be compatible with $\widehat{x}_{i'} = \widehat{y}_j$ if $V_j(\widehat{y}_j) - V_j(\widehat{y}_j) = U_{i'}(\widehat{y}_j) - U_{i'}(\widehat{y}_j)$. But this, together with concavity of V_j and $U_{i'}$ would imply $V_j(\widehat{y}_j) - V_j(\widehat{y}_j + 1) = U_{i'}(\widehat{y}_j + 1) - U_{i'}(\widehat{y}_j)$, contradicting A3. Therefore $\widehat{x}_i = \widehat{y}_j$ implies $\widehat{x}_i \leq \widehat{y}_j$. The same arguments establish that $\widehat{x}_i = \widehat{y}_j$ implies $\widehat{x}_i \leq \widehat{y}_j$. Combining these establishes that $\widehat{x}_i = \widehat{y}_j \Leftrightarrow \widehat{x}_i = \widehat{y}_j$.

Suppose now that $\widehat{y}_i \neq \widehat{y}_i$ for some $m_i \in M$. Wlog let $\widehat{y}_i < \widehat{y}_i$. Let $w_j \in W$ be such that $\widehat{x}_j = \widehat{x}_i$ (the existence of such a woman is guaranteed by the market clearing condition). The result in the previous paragraph implies that $\widehat{x}_j = \widehat{y}_i$. Since \widehat{y}_i is optimal given $\widehat{d}(\bar{t}), \dots, \widehat{d}(t_{\max})$, $V_i(\widehat{y}_i) - V_i(\widehat{y}_i) \geq \widehat{d}(\widehat{y}_i) - \widehat{d}(\widehat{y}_i)$. Since \widehat{y}_i is optimal given $\widehat{d}(\bar{t}), \dots, \widehat{d}(t_{\max})$, $V_i(\widehat{y}_i) - V_i(\widehat{y}_i) \leq \widehat{d}(\widehat{y}_i) - \widehat{d}(\widehat{y}_i)$. Since \widehat{x}_j is optimal given $\widehat{d}(\bar{t}), \dots, \widehat{d}(t_{\max})$, $U_j(\widehat{y}_i) - U_j(\widehat{y}_i) \leq \widehat{d}(\widehat{y}_i) - \widehat{d}(\widehat{y}_i)$. Since \widehat{x}_j is optimal given $\widehat{d}(\bar{t}), \dots, \widehat{d}(t_{\max})$, $U_j(\widehat{y}_i) - U_j(\widehat{y}_i) \geq \widehat{d}(\widehat{y}_i) - \widehat{d}(\widehat{y}_i)$. These four inequalities can only hold simultaneously if

$V_i(\hat{y}_i) - V_i(\hat{y}_i) = \hat{d}(\hat{y}_i) - \hat{d}(\hat{y}_i) = \hat{d}(\hat{y}_i) - \hat{d}(\hat{y}_i) = U_j(\hat{y}_i) - U_j(\hat{y}_i)$. Concavity of V_i and U_j then implies $V_i(\hat{y}_i) - V_i(\hat{y}_i + 1) = U_j(\hat{y}_i + 1) - U_j(\hat{y}_i)$. Therefore $\hat{y}_i = \hat{y}_i \quad \forall \quad m_i \in M$. Then the result obtained in the previous paragraph establishes the claim. QED

Now we establish the main theorem, namely that the introduction of a minimum age changes equilibrium decisions of women and men in a simple manner if the above assumptions hold. In particular, those individuals who would have married earlier than the minimum legal age in the unconstrained market get married exactly at the minimum legal age in the constrained market, while the rest of the women and men get married at the same time as they would have in the unconstrained market.

Theorem 2: Assume A1-A3 hold. Let the unique vector of marriage choices in competitive equilibrium be $\hat{x}_1, \dots, \hat{x}_{n_w}, \hat{y}_1, \dots, \hat{y}_{n_m}$. Then for any minimal binding age $\bar{t} \in \{t_{\min} + 1, \dots, t_{\max}\}$ the unique vector of marriage choices $\hat{x}^{\bar{t}}_1, \dots, \hat{x}^{\bar{t}}_{n_w}, \hat{y}^{\bar{t}}_1, \dots, \hat{y}^{\bar{t}}_{n_m}$ in competitive equilibrium of the constrained market with minimum legal age \bar{t} satisfies $\hat{x}^{\bar{t}}_i = \bar{t}$ if $\hat{x}_i < \bar{t}$ and $\hat{x}^{\bar{t}}_i = \hat{x}_i$ if $\hat{x}_i \geq \bar{t} \quad \forall \quad w_i \in W$. Similarly, $\hat{y}^{\bar{t}}_i = \bar{t}$ if $\hat{y}_i < \bar{t}$ and $\hat{y}^{\bar{t}}_i = \hat{y}_i$ if $\hat{y}_i \geq \bar{t} \quad \forall \quad m_i \in W$.

Proof: For $\bar{t} = t_{\max}$ the claim is trivial. Let $\bar{t} \in \{t_{\min} + 1, \dots, t_{\max} - 1\}$. Let $\hat{d}(t_{\min}), \dots, \hat{d}(t_{\max})$ be a vector of endowments that together with $\hat{x}_1, \dots, \hat{x}_{n_w}, \hat{y}_1, \dots, \hat{y}_{n_m}$ constitute a competitive equilibrium of the unrestricted market (as noted in the proof of theorem 1, a competitive equilibrium always exists).

Let $W^* = \{w_i \in W : \hat{x}_i < \bar{t}\}$ and let $M^* = \{m_i \in M : \hat{y}_i < \bar{t}\}$. Define x^* to be the minimal x such that $x \geq \bar{t}$ and $\#\{m_i \in M : \hat{y}_i = x\} \neq 0$. Let $\Delta(x) = \min_{m_i \in M^*} (U_i(x) - U_i(x^*)) \quad \forall \quad x \in \{\bar{t}, \dots, x^* - 1\}$. Construct a new dowry vector \hat{d}' such that $\hat{d}'(x) = \hat{d}(x) \quad \forall \quad x \geq x^*$ and $\hat{d}'(x) = \hat{d}(x^*) - \Delta(x) \quad \forall \quad x^* > x > \bar{t}$. We claim that \hat{d}' , together with $\hat{x}_1, \dots, \hat{x}_{n_w}, \hat{y}_1, \dots, \hat{y}_{n_m}$ as constructed in the theorem constitute a competitive equilibrium of the marriage market with minimum legal age of marriage \bar{t} . By construction $\hat{d}'(\bar{t}) = 0$, $\#\{m_i \in M : \hat{y}_i = x\} = \#\{w_i \in W : \hat{x}_i = x\} \quad \forall \quad \bar{t} \leq x \leq t_{\max}$ and $\hat{x}_i \geq p_i \quad \forall \quad w_i \in W$. Furthermore, note that $\hat{d}'(x) - \hat{d}'(x') = \hat{d}(x) - \hat{d}(x') \quad \forall \quad x, x' \in \{x^*, \dots, t_{\max}\}$. But then the starting assumption that $\hat{x}_1, \dots, \hat{x}_{n_w}, \hat{y}_1, \dots, \hat{y}_{n_m}, \hat{d}(t_{\min}), \dots, \hat{d}(t_{\max})$ constitutes a competitive equilibrium of the unconstrained marriage market implies that if for some $w_i \in W \hat{x}_i \geq \bar{x}$ then

$\hat{x}_i^{\bar{t}} = \hat{x}_i$ is a better decision than any other choice from $\{x^*, \dots, t_{\max}\}$ if the dowry vector is \hat{d}' . By A1 and the definition of $\hat{d}'(x)$ for $x^* > x \geq \bar{t}$, $\hat{x}_i^{\bar{t}}$ is a better decision than any x for which $x^* > x \geq \bar{t}$ given dowry vector \hat{d}' . This concludes that $\hat{x}_i^{\bar{t}}$ is an optimal decision for $w_i \in W/W^*$ in the constrained market with minimum legal marriage age \bar{t} under dowry vector \hat{d}' . It is completely analogous to show, using A2 that $\hat{y}_i^{\bar{t}}$ is an optimal decision for $m_i \in M/M^*$ in the constrained market with minimum legal marriage age \bar{t} given dowry vector \hat{d}' . Furthermore, Lemma 2 implies that $U_i(x) - U_i(x^*) < \hat{d}(x) - \hat{d}(x^*) = \hat{d}'(x) - \hat{d}'(x^*) \quad \forall x \in \{x^* + 1, \dots, t_{\max} + 1\}$ and $w_i \in W^*$ and that $V_i(x^*) - V_i(x) \geq \hat{d}(x) - \hat{d}(x^*) = \hat{d}'(x) - \hat{d}'(x^*) \quad \forall x \in \{x^* + 1, \dots, t_{\max} + 1\}$ and $m_i \in M^*$. By A2 and the definition of $\hat{d}'(x)$ for $x^* > x \geq \bar{t}$, it is also true that $V_i(\bar{t}) - V_i(x^*) \geq \hat{d}'(x^*) - \hat{d}'(\bar{t}) = \hat{d}'(x^*)$. This concludes that $\hat{x}_i^{\bar{t}}$ is an optimal decision for $m_i \in M^*$ in the constrained market with minimum legal marriage age \bar{t} under dowry vector \hat{d}' . Consider now any $m_j \in W^*$. Define x^{**} to be the maximal x such that $x < \bar{t}$ and $\#\{w_i \in W : \hat{x}_i = x\} \neq 0$. By Lemma 2 $U_j(x^*) - U_j(x^{**}) \leq \hat{d}(x^{**}) - \hat{d}(x^*)$. Also by Lemma 2 $V_i(x^{**}) - V_i(x^*) \geq \hat{d}(x^{**}) - \hat{d}(x^*) \quad \forall m_i \in M^*$. This implies $V_i(x^{**}) - V_i(x^*) \geq U_j(x^*) - U_j(x^{**}) \quad \forall m_i \in M^*$. The concavity of the utility functions and $x^{**} < \bar{t} \leq x^*$ then imply $V_i(\bar{t}) - V_i(x^*) \geq U_j(x^*) - U_j(\bar{t}) \quad \forall m_i \in M^*$. Then by the construction of \hat{d}' it holds that $U_j(x^*) - U_j(\bar{t}) \leq \hat{d}'(\bar{t}) - \hat{d}'(x^*)$. Combining the above findings concludes that $\hat{x}_j^{\bar{t}}$ is an optimal decision for $w_j \in W^*$ in the constrained market with minimum legal marriage age \bar{t} given dowry vector \hat{d}' . This establishes that $\hat{x}_1^{\bar{t}}, \dots, \hat{x}_{n_w}^{\bar{t}}, \hat{y}_1^{\bar{t}}, \dots, \hat{y}_{n_m}^{\bar{t}}$ and \hat{d}' constitute a competitive equilibrium of the marriage market with minimum legal age of marriage \bar{t} . Then by Theorem 1 marriage time choices in every competitive equilibrium of the constrained market with minimum legal marriage age \bar{t} are $\hat{x}_1^{\bar{t}}, \dots, \hat{x}_{n_w}^{\bar{t}}, \hat{y}_1^{\bar{t}}, \dots, \hat{y}_{n_m}^{\bar{t}}$. QED

Table 1. Summary Statistics

| | All | First married at 15 or younger | First married older than 15 | $t_{\Delta 3,4}$ | Menarche 11-13 | Menarche 14 | Menarche 15-17 | $t_{\Delta 4,5}$ | $t_{\Delta 4,6}$ |
|---|-------------|--------------------------------------|--------------------------------|------------------|-------------------|----------------|-------------------|------------------|------------------|
| | (1) | (2) | (3) | | (4) | (5) | (6) | | |
| Age | 33.619 | 34.741 | 32.368 | -11.02 | 33.828 | 33.611 | 33.466 | -0.80 | -1.29 |
| Height (cm) | 150.033 | 149.957 | 150.117 | 0.63 | 150.109 | 149.974 | 150.019 | -0.43 | -0.27 |
| Hindu | 0.113 | 0.087 | 0.141 | 3.83 | 0.118 | 0.117 | 0.103 | -0.06 | -0.90 |
| <u>Family Background</u> | | | | | | | | | |
| Father farmer | 0.764 | 0.766 | 0.762 | -0.20 | 0.765 | 0.758 | 0.770 | -0.32 | 0.21 |
| Value father's property | 70945 | 65390 | 77136 | 1.56 | 66414 | 66273 | 80790 | -0.02 | 1.52 |
| Father business | 0.068 | 0.061 | 0.076 | 1.36 | 0.069 | 0.063 | 0.074 | -0.47 | 0.31 |
| Father's schooling | 2.718 | 2.459 | 3.007 | 3.39 | 2.894 | 2.771 | 2.889 | -0.61 | -1.00 |
| Mother's schooling | 0.826 | 0.642 | 1.031 | 4.62 | 0.789 | 0.843 | 0.842 | 0.53 | 0.52 |
| Number of siblings | 4.708 | 4.678 | 4.740 | 0.68 | 4.718 | 4.753 | 4.663 | 0.32 | -0.48 |
| Mom survived to 50 | 0.777 | 0.787 | 0.765 | -1.23 | 0.763 | 0.802 | 0.761 | 1.72 | -0.09 |
| Dad survived to 50 | 0.889 | 0.889 | 0.890 | 0.03 | 0.880 | 0.893 | 0.894 | 0.76 | 0.82 |
| <u>School Outcomes</u> | | | | | | | | | |
| Literate | 0.349 | 0.269 | 0.438 | 8.17 | 0.331 | 0.365 | 0.379 | 1.31 | 1.67 |
| Highest class attended | 2.591 | 1.959 | 3.296 | 9.57 | 2.533 | 2.689 | 2.946 | 0.91 | 1.97 |
| Quit school for marriage (among ever enrolled) | 0.405 | 0.446 | 0.369 | -2.53 | 0.436 | 0.419 | 0.360 | -0.45 | -1.99 |
| Enrolled at age 9 | 0.482 | 0.425 | 0.545 | 5.52 | 0.489 | 0.485 | 0.472 | -0.17 | -0.62 |
| <u>Marriage Outcomes</u> | | | | | | | | | |
| Age of marriage | 15.743 | 13.578 | 18.155 | 50.94 | 14.710 | 15.718 | 16.728 | 6.34 | 12.52 |
| Value of dowry | 3187 | 2449 | 4013 | 5.46 | 3164 | 3126 | 3271 | -0.11 | 0.30 |
| Spouse education level | 6.883 | 6.357 | 7.424 | 5.79 | 6.845 | 6.992 | 6.781 | 0.65 | -0.26 |
| Spouse's father's education | 1.585 | 1.283 | 1.942 | 4.67 | 1.678 | 1.631 | 1.453 | -0.26 | -1.27 |
| Spouse wealthier at marriage | 0.579 | 0.559 | 0.601 | 1.99 | 0.568 | 0.576 | 0.589 | 0.31 | 0.78 |
| Spouse age at marriage | 36.293 | 37.351 | 35.114 | -4.41 | 36.967 | 35.744 | 36.331 | -1.93 | -0.96 |
| Husband/in-laws taken her money or possessions or prevented her from leaving bari | 0.319 | 0.308 | 0.331 | 1.14 | 0.341 | 0.308 | 0.313 | -1.30 | -1.09 |
| Participates in major family decisions | 0.881 | 0.897 | 0.864 | -2.29 | 0.855 | 0.903 | 0.881 | 2.74 | 1.36 |
| <u>Healthcare Outcomes</u> | | | | | | | | | |
| Likelihood prenatal care | 0.385 | 0.314 | 0.465 | 8.65 | 0.325 | 0.427 | 0.392 | 4.75 | 3.09 |
| Mean visits to antenatal clinic | 1.364 | 1.145 | 1.608 | 6.88 | 1.187 | 1.475 | 1.400 | 3.45 | 2.60 |
| Likelihood anti-tetanus shot | 0.547 | 0.483 | 0.618 | 6.27 | 0.466 | 0.597 | 0.565 | 4.95 | 3.60 |
| <u>Adult Health Outcomes</u> | | | | | | | | | |
| Diabetes | 0.071 | 0.076 | 0.066 | -0.84 | 0.065 | 0.066 | 0.084 | 0.08 | 1.34 |
| Arthritis | 0.406 | 0.450 | 0.356 | -4.37 | 0.382 | 0.411 | 0.421 | 1.12 | 1.46 |
| Urinary infection | 0.173 | 0.179 | 0.166 | -0.83 | 0.180 | 0.161 | 0.181 | -0.93 | 0.05 |
| Respiratory disease | 0.054 | 0.059 | 0.047 | -1.26 | 0.057 | 0.057 | 0.048 | -0.01 | -0.74 |
| Gastritis | 0.485 | 0.498 | 0.470 | -1.30 | 0.473 | 0.491 | 0.491 | 0.67 | 0.63 |
| Other health condition | 0.088 | 0.103 | 0.072 | -2.48 | 0.098 | 0.085 | 0.084 | -0.82 | -0.88 |
| Overall health (self-rated 1-4) | 1.816 | 1.852 | 1.775 | -1.53 | 1.869 | 1.774 | 1.813 | -1.53 | -0.88 |
| <i>Observations</i> | <i>2101</i> | <i>993</i> | <i>1108</i> | | <i>634</i> | <i>776</i> | <i>691</i> | | |

Notes: Data from the 1996 Matlab Health and Social Survey (MHSS). Literate is constructed from survey question on whether respondent can read a Bangla newspaper and write a letter in Bangla: (a) easily, (b) with difficulty, or (c) not at all. Respondents defined as literate if they report (a) or (b) to both questions. "Likelihood prenatal care" is indicator of prenatal care averaged over all pregnancies; "average visits to antenatal clinic" is number of visits to antenatal clinic averaged over all pregnancies; "likelihood anti-tetanus shot" is indicator of prenatal anti-tetanus shot averaged over all pregnancies. Whether husband/inlaws have taken money or possessions and whether woman participates in family decisions is only available for married women, hence 11.74% of ever- but not currently married women are excluded from these means. Certain variables, including all or fraction of pregnancies and experience with in-laws, do not necessarily pertain to first marriage. 7.5% of respondents have been married more than once.

Table 2. First-stage regression: Age of first marriage

| | (1) | (2) | (3) | (4) | (5) | (6) |
|------------------------------|--------------------|---------------------|---------------------|---------------------|---------------------|----------------------|
| Age of menarche | 0.743 (0.063)** | | 0.738 (0.061)** | 0.803 (0.065)** | 0.682 (0.087)** | 0.789 (0.088)** |
| Menarche 11 | | -3.803 (1.015)** | | | | |
| Menarche 12 | | -2.219 (0.384)** | | | | |
| Menarche 13 | | -2.534 (0.245)** | | | | |
| Menarche 14 | | -1.485 (0.232)** | | | | |
| Menarche 15 | | -0.685 (0.245)** | | | | |
| Height (cm) | | | 0.010 (0.012) | 0.009 (0.012) | 0.008 (0.015) | 0.007 (0.017) |
| Age | | | -0.121 (0.044)** | -0.134 (0.044)** | -0.175 (0.065)** | -0.058 (0.059) |
| Value father's property | | | -0.001 (0.034) | -0.019 (0.036) | -0.004 (0.043) | -0.018 (0.051) |
| Contraceptive intervention | | | 0.255 (0.125)* | 1.69 (1.762) | 0.141 (0.182) | 0.354 (0.173)* |
| Father business | | | -0.091 (0.230) | -0.061 (0.236) | -0.295 (0.302) | 0.030 (0.343) |
| Father farmer | | | -0.159 (0.162) | -0.183 (0.169) | 0.064 (0.252) | -0.326 (0.211) |
| Father's schooling | | | 0.038 (0.021) | 0.028 (0.021) | 0.034 (0.027) | -0.007 (0.036) |
| Mother's schooling | | | 0.130 (0.041)** | 0.108 (0.042)* | 0.118 (0.047)* | 0.058 (0.092) |
| Hindu | | | 0.936 (0.215)** | 0.776 (0.270)** | 1.313 (0.361)** | 0.777 (0.266)** |
| Mom alive age 50 | | | 0.219 (0.217) | 0.210 (0.216) | 0.564 (0.315) | -0.064 (0.300) |
| Dad alive age 50 | | | -0.190 (0.237) | -0.231 (0.247) | -0.452 (0.318) | -0.033 (0.330) |
| <i>Village fixed effects</i> | <i>No</i> | <i>No</i> | <i>No</i> | <i>Yes</i> | <i>No</i> | <i>No</i> |
| | | | | | <i>In school at</i> | <i>Out of school</i> |
| <i>Universe</i> | <i>All</i> | <i>All</i> | <i>All</i> | <i>All</i> | <i>age 9</i> | <i>at age 9</i> |
| <i>F-stat</i> | <i>140.11</i> | <i>34.18</i> | <i>145.97</i> | <i>152.01</i> | <i>61.75</i> | <i>81.09</i> |
| <i>Observations</i> | <i>2101</i> | <i>2101</i> | <i>2101</i> | <i>2101</i> | <i>1012</i> | <i>1089</i> |

Note: Data from the 1996 Matlab Health and Social Survey (MHSS). Ordinary least squares regression, dependent variable is age at marriage. Standard errors in parentheses. Robust standard errors account for sample clustering (bars). Regressions also include 5-year age dummies. Results robust to single year age fixed effects. Value of father's property in units of 100,000 Taka.

Table 3. Effect of Marriage Age on Schooling and Literacy

| Dependent Variable: | Literacy | | | | Highest Grade Attained | | | | Enrolled in school age 8 | |
|---------------------------------|------------------------------------|--------------------|------------------------|--------------------|------------------------|-------------------------------|------------------------|--------------------|--------------------------|--------------------|
| | Literacy | | Highest Grade Attained | | Literacy | | Highest Grade Attained | | Enrolled in school age 8 | |
| Universe: | <i>Enrolled in school at age 9</i> | | | | <i>Full sample</i> | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| | OLS | IV | OLS | IV | OLS | IV | OLS | IV | OLS | IV |
| Age of marriage | 0.244 (0.028)** | 0.216 (0.102)* | 0.022 (0.004)** | 0.041 (0.019)* | 0.010 (0.013) | 0.085 (0.048) [†] | -0.007 (0.002)** | 0.020 (0.009)* | 0.011 (0.003)** | -0.003 (0.012) |
| Height (cm) | 0.032 (0.012)** | 0.032 (0.012)** | 0.004 (0.003) | 0.004 (0.003) | 0.015 (0.006)** | 0.015 (0.006)* | 0.002 (0.001) | 0.002 (0.001) | 0.005 (0.002)** | 0.005 (0.002)** |
| Age | -0.112 (0.052)* | -0.118 (0.056)* | 0.002 (0.010) | 0.006 (0.011) | 0.003 (0.027) | 0.004 (0.028) | 0.002 (0.005) | 0.002 (0.005) | -0.009 (0.007) | -0.011 (0.007) |
| Value father's property | 0.006 (0.040) | 0.007 (0.040) | 0.002 (0.007) | 0.001 (0.007) | 0.129 (0.075) | 0.137 (0.077) | 0.018 (0.014) | 0.014 (0.014) | 0.019 (0.006)** | 0.019 (0.006)** |
| Contraceptive intervention area | 0.257 (0.153) | 0.261 (0.153) | 0.015 (0.029) | 0.012 (0.029) | 0.464 (0.175)** | 0.441 (0.178)* | 0.042 (0.029) | 0.040 (0.029) | 0.008 (0.021) | 0.011 (0.021) |
| Father business | 0.611 (0.261)* | 0.603 (0.261)* | 0.062 (0.044) | 0.068 (0.046) | 0.073 (0.083) | 0.084 (0.086) | 0.017 (0.016) | 0.022 (0.017) | 0.106 (0.037)** | 0.105 (0.038)** |
| Father farmer | 0.226 (0.212) | 0.229 (0.211) | 0.059 (0.041) | 0.057 (0.041) | -0.058 (0.025)* | -0.070 (0.027)** | 0.001 (0.005) | 0.001 (0.005) | 0.059 (0.025)* | 0.056 (0.025)* |
| Father's schooling | 0.172 (0.022)** | 0.173 (0.022)** | 0.021 (0.004)** | 0.021 (0.004)** | 0.113 (0.014)** | 0.112 (0.014)** | 0.016 (0.003)** | 0.015 (0.003)** | 0.040 (0.003)** | 0.040 (0.003)** |
| Mother's schooling | 0.231 (0.039)** | 0.235 (0.041)** | 0.013 (0.007)* | 0.011 (0.007) | 0.222 (0.032)** | 0.244 (0.033)** | 0.015 (0.005)** | 0.016 (0.005)** | 0.035 (0.006)** | 0.037 (0.006)** |
| Hindu | 0.205 (0.299) | 0.241 (0.340) | 0.048 (0.049) | 0.024 (0.056) | 0.063 (0.114) | 0.098 (0.128) | 0.007 (0.020) | 0.000 (0.022) | -0.082 (0.033)* | -0.069 (0.035)* |
| Mom survived to age 50 | 0.458 (0.237) | 0.473 (0.240)* | 0.016 (0.045) | 0.006 (0.046) | 0.165 (0.106) | 0.186 (0.110) | 0.010 (0.021) | 0.010 (0.021) | 0.052 (0.029) | 0.055 (0.029) |
| Dad survived to age 50 | 0.257 (0.261) | 0.245 (0.262) | 0.004 (0.050) | 0.012 (0.050) | 0.113 (0.120) | 0.094 (0.125) | 0.006 (0.023) | 0.005 (0.023) | 0.046 (0.035) | 0.044 (0.036) |
| Observations | 1012 | 1012 | 1012 | 1012 | 2101 | 2101 | 2101 | 2101 | 2101 | 2101 |

Notes: Data from the 1996 Matlab Health and Social Survey (MHSS). Columns 1, 3, 5, 7 and 9 are ordinary least squares regression estimates; columns 2, 4, 6, 8 and 10 are instrumental variables estimates, instrument is age of menarche. All regressions also control for indicators of whether each parent is currently under age 50, and five-year cohort dummies. Robust standard errors account for clustering at bari level. Dependent variable in columns 3 and 4 is constructed from survey question on whether respondent can read a Bangla newspaper and write a letter in Bangla: (a) easily, (b) with difficulty, or (c) not at all. Respondents defined as literate if they report (a) or (b) to both questions. Results robust to more stringent criteria for literacy.

Table 4. Influence of menarche on schooling according to sex-specific birth order and observation of religious customs

| | Age of marriage (1) | Age quit school (3) | Highest grade attended (2) | Age quit school | |
|--|------------------------------|------------------------------|-------------------------------|--|---|
| | | | | (4) | (5) |
| Age of menarche | 0.397 (0.114)** | 0.934 (0.124)** | 0.241 (0.108)* | 0.198 (0.087)* | 0.368 (0.166)* |
| Sex-specific birth order | 4.698 (2.411) | 6.609 (2.982)* | 4.157 (2.355) | | |
| (Sex-specific birth order)* (Age of menarche) | -0.329 (0.163)* | -0.387 (0.201) | -0.303 (0.160)* | | |
| Number female siblings | -0.111 (0.095) | -0.036 (0.108) | -0.08 (0.093) | | |
| Number siblings | 0.058 (0.054) | 0.015 (0.063) | 0.05 (0.058) | | |
| | <i>>=1 female sibling</i> | <i>>=1 female sibling</i> | <i>>=1 female sibling</i> | <i>Always wear head scarf outside bari</i> | <i>Do not always wear head scarf outside bari</i> |
| <i>Universe:</i> | | | | | |
| <i>Observations:</i> | 851 | 851 | 851 | 808 | 284 |

Note: Data from the 1996 Matlab Health and Social Survey (MHSS). All regressions restricted to subsample of girls who are in school at age 9. To standardize for family size, sex-specific birth order is measured as number of older female siblings divided by total number of female siblings. All estimates robust to including year of birth or five-year cohort dummies.

Table 5. Effect of Marriage Age on Utilization of Reproductive Health Care Services

| | Prenatal care | | Number antenatal visits | | Whether received anti-tetanus shot | | Restriction of mobility and consumption | | Whether participates in major family decisions | |
|--------------------------------|---------------------|---------------------|-------------------------|---------------------|------------------------------------|---------------------|---|--------------------|--|-------------------------------|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| Age of marriage | 0.037 (0.016)* | 0.030 (0.012)* | 0.087 (0.062) | 0.142 (0.060)* | 0.065 (0.021)** | 0.043 (0.018)* | -0.011 (0.023) | -0.036 (0.017)* | 0.013 (0.015) | 0.028 (0.016) [†] |
| Height (cm) | -0.002 (0.002) | 0.001 (0.002) | -0.005 (0.008) | -0.006 (0.007) | -0.001 (0.003) | -0.001 (0.002) | -0.007 (0.003)** | -0.001 (0.003) | -0.001 (0.002) | 0.001 (0.002) |
| Age | -0.026 (0.009)** | -0.022 (0.007)** | -0.066 -0.04 | -0.017 -0.03 | -0.008 -0.012 | -0.011 -0.01 | 0.012 -0.012 | 0.002 -0.011 | 0.015 -0.008 | 0.018 (0.008)* |
| Contraceptive intervention | 0.006 (0.006) | 0.005 (0.007) | 0.029 (0.024) | 0.020 (0.030) | 0.004 (0.007) | 0.016 (0.010) | 0.002 (0.008) | 0.007 (0.012) | 0.007 (0.003) | 0.006 (0.008) |
| Value father's land | 0.287 (0.023)** | 0.290 (0.021)** | 0.778 (0.094)** | 0.792 (0.094)** | 0.261 (0.032)** | 0.317 (0.030)** | 0.033 (0.032) | 0.079 (0.033)* | 0.007 (0.021) | -0.022 (0.024) |
| Father business | 0.025 (0.038) | -0.091 (0.054) | 0.223 (0.159) | -0.496 (0.191)** | 0.083 (0.050) | -0.177 (0.071)* | 0.030 (0.055) | 0.143 (0.078) | 0.057 (0.028)* | -0.018 (0.057) |
| Father farmer | -0.010 -0.032 | 0.020 -0.023 | -0.121 -0.153 | 0.064 -0.098 | 0.044 -0.044 | 0.009 -0.033 | 0.084 -0.043 | 0.017 -0.038 | 0.024 -0.033 | 0.034 -0.029 |
| Father schooling | 0.003 (0.003) | 0.009 (0.004)* | 0.007 (0.016) | 0.032 (0.016) | 0.002 (0.004) | 0.009 (0.006) | 0.003 (0.005) | 0.005 (0.007) | 0.000 (0.003) | 0.002 (0.005) |
| Mother schooling | 0.001 (0.006) | -0.008 (0.010) | 0.026 (0.027) | 0.056 (0.052) | -0.011 (0.008) | -0.005 (0.013) | 0.007 (0.008) | 0.014 (0.017) | 0.000 (0.005) | -0.031 (0.014)* |
| Hindu | -0.021 (0.046) | 0.016 (0.032) | -0.068 (0.267) | 0.014 (0.140) | -0.103 (0.059) | -0.001 (0.043) | -0.075 (0.059) | -0.056 (0.047) | -0.100 (0.049)* | -0.030 (0.037) |
| Mom alive age 50 | -0.001 (0.038) | -0.045 (0.029) | -0.168 (0.161) | -0.260 (0.134) | -0.015 (0.051) | -0.106 (0.041)** | -0.058 (0.057) | -0.101 (0.051)* | 0.015 (0.036) | -0.027 (0.033) |
| Dad alive age 50 | 0.045 (0.039) | -0.055 (0.039) | 0.074 (0.154) | 0.025 (0.138) | -0.005 (0.058) | 0.011 (0.049) | -0.005 (0.061) | -0.010 (0.055) | 0.032 (0.040) | -0.056 (0.033) |
| <i>Enrolled in school at 9</i> | <i>Yes</i> | <i>No</i> | <i>Yes</i> | <i>No</i> | <i>Yes</i> | <i>No</i> | <i>Yes</i> | <i>No</i> | <i>Yes</i> | <i>No</i> |
| <i>Observations</i> | <i>1011</i> | <i>1084</i> | <i>1011</i> | <i>1084</i> | <i>1011</i> | <i>1084</i> | <i>919</i> | <i>933</i> | <i>911</i> | <i>925</i> |

Notes: Data from the 1996 Matlab Health and Social Survey (MHSS). Instrumental variables estimates, instruments are age of menarche and age of menarche interacted with contraceptive intervention dummy. Dependent variable in columns 1 and 2 is indicator of prenatal care averaged over all pregnancies; dependent variable in columns 3 and 4 is number of visits to antenatal clinic averaged over all pregnancies; dependent variable in columns 5 and 6 is indicator of prenatal anti-tetanus shot averaged over all pregnancies; dependent variable in columns 7 and 8 is binary indicator of whether respondent reports that husband or inlaws have ever prevented her from leaving bari for work or family visits, or have taken away her money or possessions; dependent variable in columns 9 and 10 is binary indicator of whether respondent reports that she participates in major family decisions. The dependent variable in the last two columns is only available for married women, hence 11.74% of ever- but not currently married women are excluded from these regressions. In addition, 16 married respondents have missing values for whether participate in family decisions. Certain variables, including all or fraction of pregnancies and experience with in-laws, do not necessarily pertain to first marriage. 7.5% of respondents have been married more than once.

Table 6. Age of Marriage and Marriage Market Outcomes

| | Value dowry | Spouse highest grade passed [†] | Spouse's father's education ^{††} | Spouse wealthier at marriage | Spouse age |
|------------------------------------|-----------------------------------|--|---|------------------------------------|--------------------|
| | (1) | (2) | (3) | (5) | (4) |
| Age of marriage | 343.234 (191.318) [†] | 0.047 (0.158) | -0.045 (0.111) | -0.006 (0.021) | -0.519 (0.452) |
| Height (cm) | 23.830 (22.897) | 0.016 (0.015) | -0.003 (0.011) | -0.003 (0.002) | -0.069 (0.041) |
| Age in years | -337.045 (52.907)** | -0.063 (0.071) | -0.018 (0.053) | -0.009 (0.009) | 0.626 (0.182)** |
| Contraceptive intervention | 764.413 (274.842)** | 0.604 (0.195)** | 0.146 (0.155) | 0.004 (0.024) | -0.016 (0.484) |
| Value father's land | 26.840 (99.173) | 0.097 (0.043)* | -0.012 (0.045) | 0.015 (0.007)* | 0.188 (0.156) |
| Father business | 1459.563 (821.427) | -0.111 (0.333) | 0.116 (0.289) | 0.078 (0.045) | 0.689 (0.866) |
| Father farmer | 349.843 (397.548) | 0.060 (0.258) | -0.178 (0.173) | 0.153 (0.029)** | 0.554 (0.633) |
| Father schooling | 42.967 (46.388) | 0.158 (0.028)** | 0.174 (0.029)** | -0.003 (0.004) | 0.067 (0.083) |
| Mother schooling | -8.590 (107.511) | 0.214 (0.053)** | 0.078 (0.057) | 0.000 (0.007) | -0.129 (0.147) |
| Hindu | 4969.459 (734.311)** | 0.337 (0.315) | 0.486 (0.274) | -0.098 (0.037)** | 2.356 (0.859)** |
| Mom alive age 50 | -104.591 (506.990) | 0.594 (0.295)* | 0.576 (0.191)** | 0.000 (0.035) | -0.125 (0.767) |
| Dad alive age 50 | 660.828 (364.151) | 0.091 (0.307) | -0.037 (0.248) | 0.055 (0.040) | -0.725 (0.759) |
| <i>Year of birth fixed effects</i> | <i>Yes</i> | <i>No</i> | <i>No</i> | <i>No</i> | <i>No</i> |
| <i>Observations</i> | <i>1846</i> | <i>1125</i> | <i>1559</i> | <i>1852</i> | <i>1852</i> |

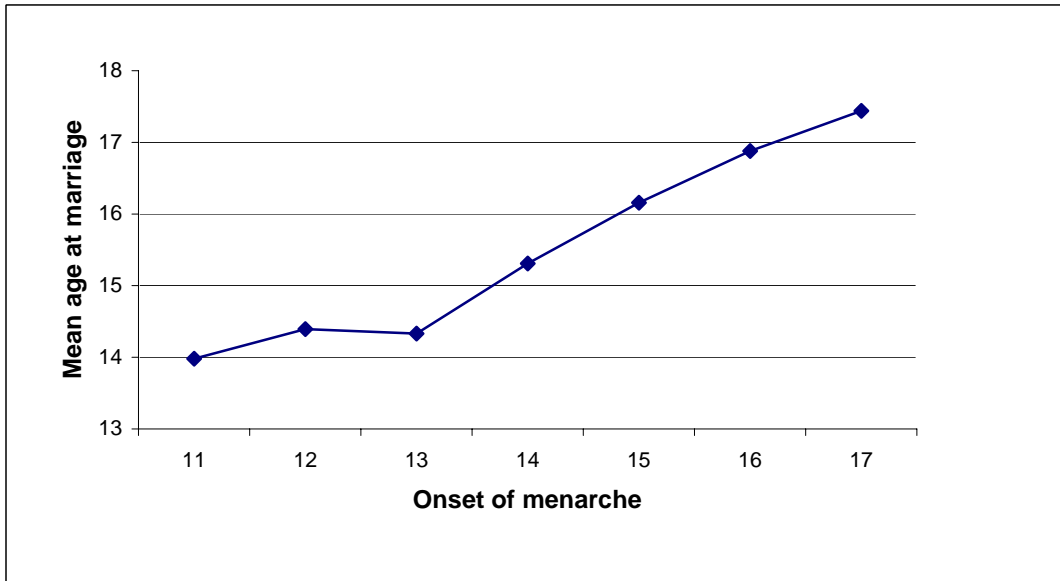
Notes: Data from the 1996 Matlab Health and Social Survey (MHSS). Instrumental variables estimates, instrument is of age of menarche. All regressions also include 5-year cohort dummies. Robust standard errors account for clustering at bari. Value of dowry collected from following survey question: "What was the total value of dowry from your [] marriage?" asked of each of respondent's marriages. Whether value given reflects 1996 value or value at time of marriage is ambiguous, particularly since two-thirds of dowries include in-kind transfers such as jewelry, land and animals, so age of birth fixed effects used to account for potential nominal valuations. [†]Number of observations reflects high rate of non-response for dependent variable. ^{††} Asked of current spouses only, so column 3 includes only women married to first spouse in 1996.

Table 7. Predicted effect of age of consent laws on average female education in Matlab

| | Age 11 | Age 12 | Age 13 | Age 14 | Age 15 | Age 16 | Age 17 |
|--|--------|--------|--------|--------|--------|--------|--------|
| <i>Beta</i> (<i>Menarche at t</i>) | | 0.477 | 0.908 | 0.978 | 1.251 | 1.674 | 1.683 |
| <i>Standard error</i> | | (0.68) | (0.58) | (0.59) | (0.57) | (0.61) | (0.67) |
| <i>g(t)</i> | 0.006 | 0.052 | 0.231 | 0.360 | 0.203 | 0.096 | 0.051 |
| <i>Implied policy effect of t_{min}</i> ($\Delta\mu_E$) | | 0.003 | 0.024 | 0.044 | 0.219 | 0.576 | 0.585 |

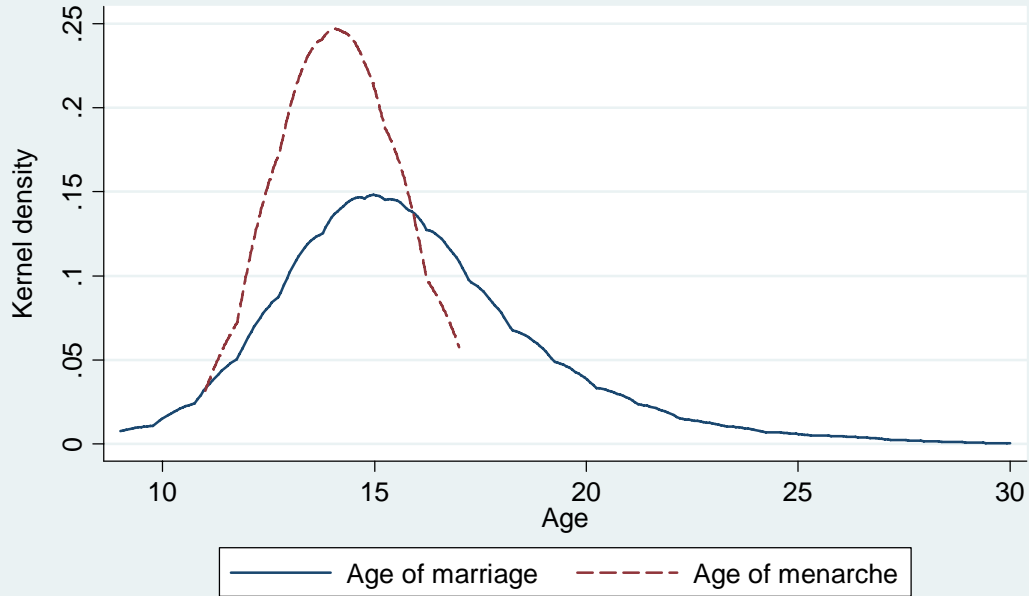
Notes: Data from the 1996 Matlab Health and Social Survey (MHSS). In first row of table, Beta refers to coefficient on age-specific dummy for menarcheal age from regression of schooling attainment on menarche. In row 3, g(t) is the distribution function of menarche at each age, t. The implied policy effect is calculated according to formula 6.1 in the paper.

Figure 1. Age of Menarche and Age of First Marriage



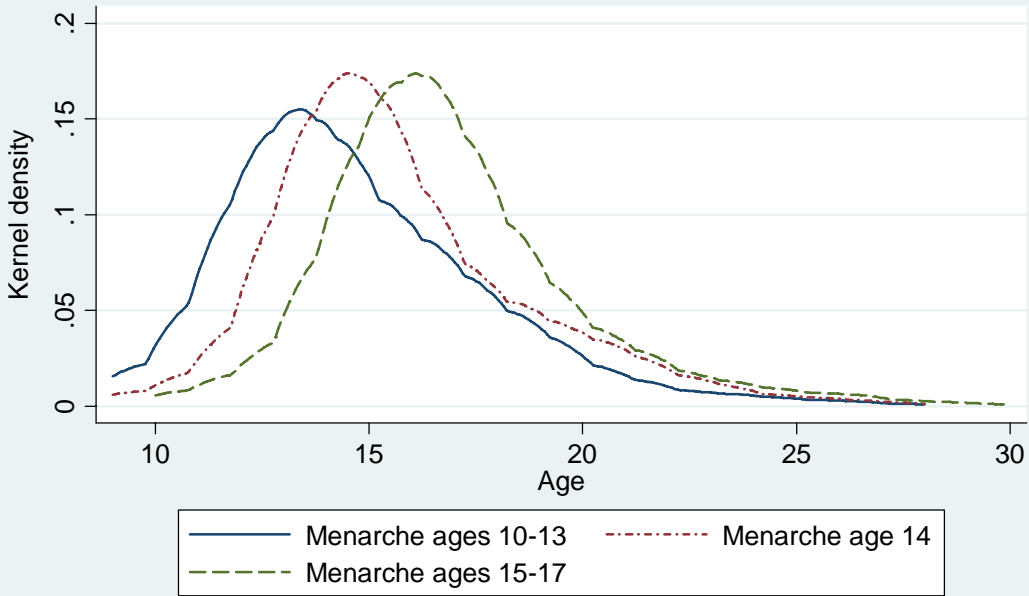
Notes: Data from the 1996 Matlab Health and Social Survey (MHSS). Sample includes ever-married women between 24 and 45 with nonmissing values for age at marriage and age at menarche, who reached menarche between 11 and 17.

Figure 2a: Density, Age of Menarche and Marriage



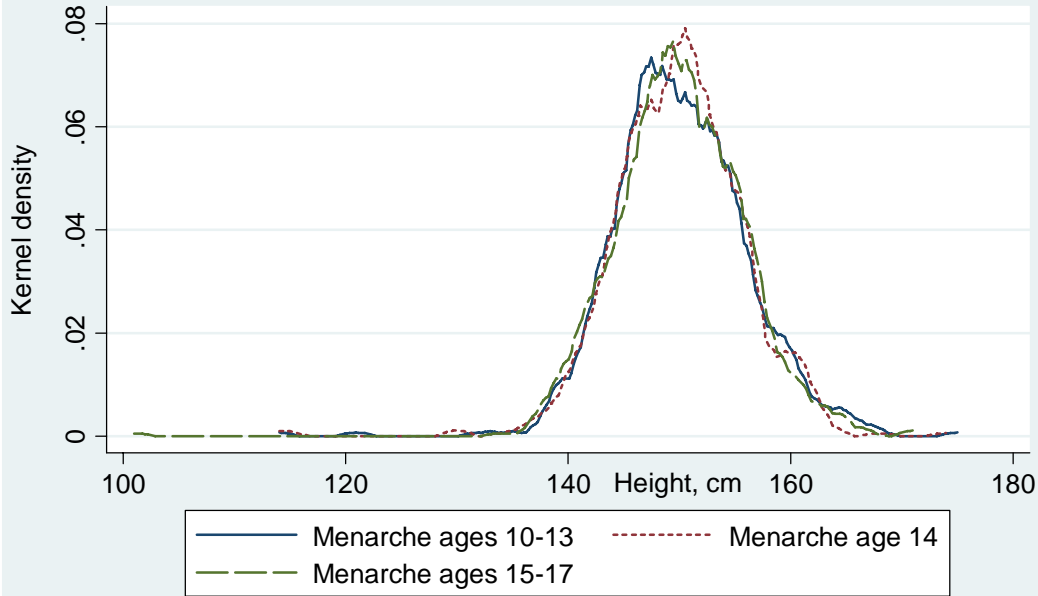
Notes: Data from the 1996 Matlab Health and Social Survey (MHSS). Sample includes ever-married women between 24 and 45 with nonmissing data, who reached menarche between 11 and 17. Epanechnikov kernel, bandwidth=1.

Figure 2b: Kernel density, Age of Marriage by Age of Menarche Group



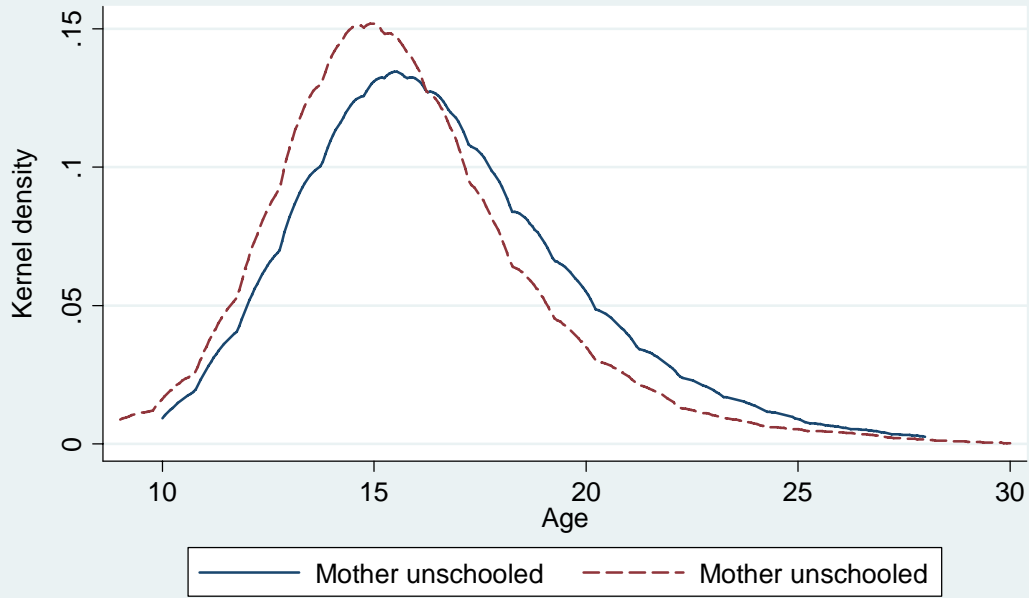
Notes: Data from the 1996 Matlab Health and Social Survey (MHSS). Sample includes ever-married women between 24 and 45 with nonmissing data, who reached menarche between 11 and 17. Epanechnikov kernel, bandwidth=1.

Figure 3: Density, Adult Height



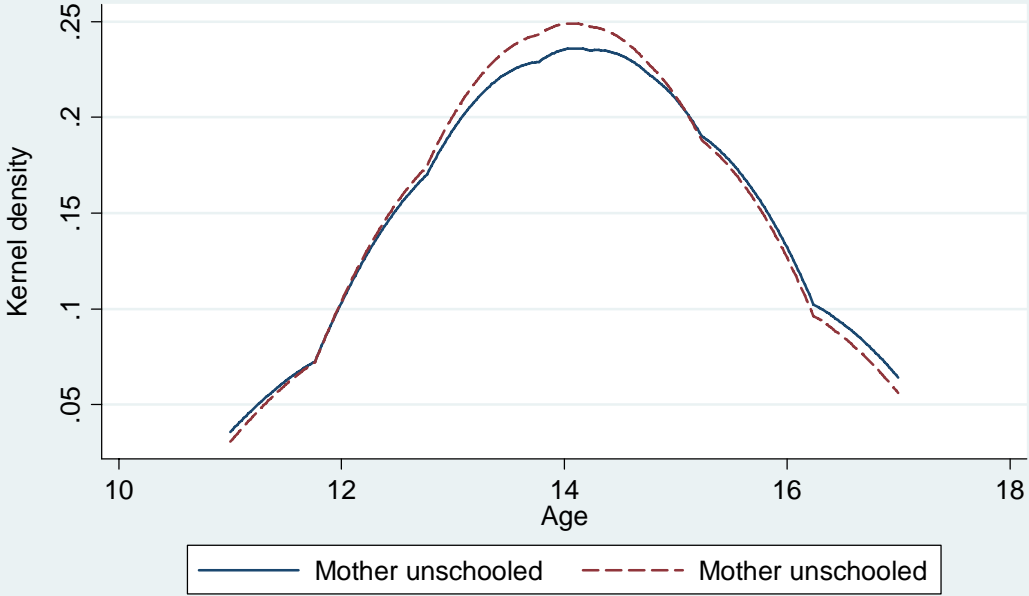
Notes: Data from the 1996 Matlab Health and Social Survey (MHSS).
Sample includes ever-married women between 24 and 45 with nonmissing data,
who reached menarche between 11 and 17. Epanechnikov kernel, bandwidth=0.8.

Figure 4a: Age of Marriage, Schooled and Unschooled Mothers



Notes: Data from the 1996 Matlab Health and Social Survey (MHSS). Sample includes ever-married women between 24 and 45 with nonmissing data, who reached menarche between 11 and 17. Epanechnikov kernel, bandwidth=1.

Figure 4b: Age of Menarche, Schooled and Unschooled Mothers



Notes: Data from the 1996 Matlab Health and Social Survey (MHSS). Sample includes ever-married women between 24 and 45 with nonmissing data, who reached menarche between 11 and 17. Epanechnikov kernel, bandwidth=1.