The Timing of Menarche as an Instrument for the Timing of Marriage

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Abstract

In this note, I revisit the use of the timing of menarche as an instrument the timing of marriage to study the effect of the latter on a host of policy-relevant outcomes, including education. I adopt two complementary approaches to understand the validity of this identification strategy in the Indian context. First, I discuss existing evidence to argue that menarche is likely to affect experiences of a young girl's life other than just the timing of her marriage. Second, I use the methodology proposed by Conley, Hansen, and Rossi (2012) to show that the two-stage least squares estimates that use the timing of menarche to instrument for the timing of marriage is not stable.

Keywords: Menarche; Marriage; Instrumental variable

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1 Introduction

In many patriarchal societies, the onset of menstruation (menarche) marks a girl's socio-biological readiness for married (Dube 1988). An important body of work exploits this cultural norm to explore the impact of marriage timing on diverse aspects of a woman's well-being, including education, autonomy, and children's human capital. To consistently estimate the effect of the age of marriage, the variation in the timing of menarche is used to isolate the exogenous variation in marriage age. This strategy was first proposed in Field and Ambrus (2008), who use it to study the effect of women's age at marriage on their educational attainment. Since then, many papers have followed this strategy to explore the effect of early marriage on a variety of policy-relevant outcomes, in (Sekhri and Debnath 2014; Chari et al. 2017; Roychowdhury and Dhamija 2018; Dhamija and Roychowdhury 2020) and outside India (Sunder 2017; Cantet 2019; Hicks and Hicks 2019) for younger cohorts.

Two assumptions are implicit in this identification strategy: (1) only affects age at marriage and not other aspects of a girl's life that could influence outcome variables, and (2) is only not affected by her socioeconomic environment. If these assumptions do not hold, estimates based on this strategy, while qualitatively useful, may be biased.

In this note, I take two approaches to explore the validity of this strategy in the Indian setting. First, I review the literature from across disciplines on the causes and effects of the onset of menstruation to understand the validity of these assumptions. This exercise suggests that menarche, being a critical transition in an adolescent girl's life, affects many experiences beyond her entry into the marriage market. In a companion paper, I establish a causal negative effect of early menarche of school enrollment (Khanna 2021). This strategy was likely valid for Field and Ambrus (2008)'s sample where 70% of the interviewed women had married within two years after their menarche. Since then, the gap between the age at menarche and age at marriage has, if anything, increased. Finally, the nutritional environment affects age at menarche, limiting the validity of menarche as an instrument if the outcome variables are also affected by nutrition.

Second, I use the methodology proposed by Conley, Hansen, and Rossi (2012) to examine if two-stage least squares estimate that use the timing of menarche to instrument for the timing of marriage is stable to plausible violations in the exclusion restriction. I find that the estimated confidence intervals around the two-stage least squares estimates under likely violations in the exclusion restriction assumption are wide and contain zero.

The rest of this note is organized as follows. Section 2 discusses evidence from existing literature to understand if the assumptions underlying this empirical strategy are valid. Section 3 discusses the stability of the two-stage least squares estimates to exclusion restriction violations. Section **??** discusses the results and conclusion.

2 Existing Evidence

Along with marking a critical biological change in a girl's body, menarche has immense social significance in many cultures, including India. The norms of a girl's engagement with her family and her community dramatically alter when she starts menstruating (Seymour 1999). This event is marked by rituals and celebrations (Dharmalingam 1994), followed by regular restrictions on her day-to-day activities during her menses (Mahon and Fernandes 2010). Since menarche marks a girl's transition into womanhood, she is considered more vulnerable to sexual harassment and is observed more carefully by her family and society. Along with the restrictions rooted in taboos related to ritual purity, menarche introduces another set of disruptions driven by the concerns for preserving the girl's purity and pushing her into the "private domain of the family" (Dube 1988). Since menarche marks a girl's childbearing readiness, it also is the point when her parents can start planning her marriage (Sheela and Audinarayana 2003).

Clearly, menarche is a well-defined and memorable event in every girl's life that could affect many of her experiences, including her entry into the marriage market. While the link between menarche and marriage is well-known, many recent studies that use qualitative and observational data often argue that menstruation is a significant barrier to girls' schooling (see for instance: Sommer (2010), Mason et al. (2013), and Sivakami et al. (2019)). In a companion paper, I establish a causal relationship between the early menarche and school enrollment and show that reaching menarche before age twelve leads to a 14.3% decline in school enrollment (Khanna 2021). In that paper, I also confirm that early menarche is associated with early marriage; the difference in the likelihood of being married at nineteen (14% point) was in the order of the difference in the enrollment rates (10% point) at nineteen.

Now the question is did menarche increase the demand for marriage because the girl is out of school, or only due to the socio-biological relevance of menarche or a combination of the two. Recent evidence shows that the former explanation is critical: using preference elicitation experiments in India, Adams and Andrew (2019) show that girls' marriage prospects start deteriorating as soon as they leave school, and early dropout accelerates early marriage. However, parents have a strong preference for delaying their daughter's marriage until eighteen, and they value her education until high school.

It is worth noting that Field and Ambrus (2008)'s sample included women born between 1951-1970, when the legal minimum age at marriage was fifteen, and often not binding. For their sample, over 70% of marriages took place within two years of menarche. In such a setting, reaching menarche would have been the only constraint to enter the marriage market. In the sample studied in Khanna (2021), 35% of the girls who had reached menarche at twelve were still not married at 22 (Figure 1).

However, margins of the education and the marriage decision that are affected by menarche have changed with time. The age at marriage consistently increased between 1950-54 and 1965-70 in South Asia (Jensen and Thornton 2003). The average age at marriage was just over sixteen for cohorts born in 1965-1970, but over eighteen for cohorts born between 1986-1996.[1] However, the

1. I calculated the average age at marriage for cohorts born in 1986-1996 using the India Human Development

age at menarche declined by three months between the cohorts who were born around 1955-64 and the cohorts that were born around 1985-90 (Pathak, Tripathi, and Subramanian 2014). Therefore, the length of time between the ages at menarche and marriage increased over this period, which opens the possibility menarche might directly affect other experiences of a young girl's life.

Lastly, age at menarche may also be affected by the socioeconomic background of the girl. For instance, Sohn (2016) finds that climate influences significant variation in the age at menarche. This association is driven by the availability of food in the tropics versus colder weather. In line with this evidence, skeletal height, weight, physical activity, and socioeconomic status are correlated with age at menarche in India (Bagga, Kulkarni, et al. 2000; Dambhare, Wagh, and Dudhe 2012; Rah et al. 2009). Globally, nutritional status in childhood possibly explains about 25% in the variation in the age at menarche (Karlberg 2002). The association between childhood nutrition and the onset of menstruation has also been confirmed via experimental evidence: results from a long-term assessment of a nutrition-based conditional cash transfer program in Nicaragua show that girls who joined the program between eleven and fourteen had a lower age at menarche, higher fertility, and lower labor force participation than those who joined the program earlier (Barham, Macours, and Maluccio 2018).

The literature that instruments age at marriage with age at menarche addresses this issue by including the women's adulthood height as a catchall control for her childhood nutritional environment. However, girls typically experience a growth spurt right before menarche, after which their growth slows down (Villamor and Jansen 2016).[2] This is the exact pattern of height growth present in the data used in the companion paper: girls who reach menarche before age twelve are taller at age eight and grow faster between ages eight and 12, but their growth spurt ends after that (Figure 2). To address this concern, when Asadullah and Wahhaj (2019) use instruments age at marriage with age at menarche in a model with sister fixed-effects, the estimates of the effect of age at marriage on completed schooling attenuate by about one-third. This result suggests that unobservable factors affect both ages at marriage and menarche, limiting the validity of menarche as an instrument.

3 Stability of the Timing of Menarche as an Instrument

To formally examine the validity of the timing of menarche as an instrument for the age at marriage, consider the following setup: the outcome of interest is years of schooling (Y), the endogenous independent variable is an indicator that the girl did not marry until she was eighteen (X), and the indicator for reaching before twelve is the instrument for the endogenous variable (Z).[3] Consider

Survey.

2. This pattern is consistent with the lack of correlation between adult height and age at menarche documented in Chari et al. (2017) for those who started menstruating between ages 10 and 15 (90% of their sample). They find a positive association between adult height and age menarche for the rest of the sample, consistent with menarche ending the growth spurt.

3. These variables are different from the ones considered in Field and Ambrus (2008) to fully utilize the information available in the Young Lives study. Instead of using age at marriage, an indicator that the girl is unmarried until

the probability limit of the two-stage least squares estimator:

$$plim\beta^{2sls} = \underbrace{\beta}_{populationparameter} + \underbrace{\frac{Cov(Z,U)}{Cov(Z,X)}}_{bias}, \tag{3.1}$$

where U is the error term. If the incidence of early menarche does not independently affect educational attainment, the two-stage least squares estimator is consistent. However, if the relationship between early menarche and educational attainment is negative (that is, $Cov(Z,U) < 0$) and $Cov(Z,X) < 0$, then the two-stage least squares estimator overestimates the true parameter. However, if the size of the positive bias is not large, the estimated effect is still qualitatively useful.

Following Conley, Hansen, and Rossi (2012), I seek to understand the validity of the instrument to the plausible violation in the exclusion restriction through the lens of the following population model:

$$Y = X\beta + Z\kappa + \epsilon. \tag{3.2}$$

A violation of the exclusion restriction would imply that κ is not zero. Under certain assumptions on the point estimate of κ or the distribution it is drawn from, one can estimate bounds around the two-stage least squares estimate. More specifically, if the true value of κ, say κ_0, was known, then we could estimate β by subtracting $Z\kappa_0$ from both sides of the equation 3.2:

$$Y - Z\kappa_0 = X\beta + \epsilon. \tag{3.3}$$

Next, we can use the usual asymptotic approximations to estimate 95% confidence intervals around β under the assumption that $\kappa = \kappa_0$. However, we do not know κ_0. Let's assume that κ is drawn from the support G, and the true value is $\kappa_0 \in G$. For all points in the support G, one can estimate the 95% confidence interval around β^{IV} using two methods. The union of confidence intervals method assumes that only the support of κ is known, and the union of confidence intervals corresponding around β^{IV} for different values of κ in G will contain the population parameter. A primary drawback of this methodology is that the confidence intervals are often too wide. A second methodology discussed by Conley, Hansen, and Rossi (2012) assumes that κ is a random draw from a known distribution, and the knowledge of this distribution is used to compute the 95% bounds around the population parameter.

I use two data sources to use this methodology to discuss the validity of early menarche as an instrument for early marriage. First, to get a likely estimate for κ, I use data collected by the Young Lives longitudinal study that follows two cohorts of children in Andhra Pradesh over the course of their childhood, and focuses on the older cohort that was born in 1994-95.[4] Importantly for the purpose of this note, I have established a causal relationship between early menarche and schooling using these data in a companion paper. I present results from two specifications in this

eighteen is used as the endogenous variable as all girls were not married by the fifth survey round. Details of this survey are described below.

4. Andhra Pradesh was split into Andhra Pradesh and Telangana in 2014. There are about 1,000 children in this cohort.

step: one with sampling site fixed effects and one with district fixed effects (the specification that can be estimated with the IHDS data).[5]

Next, I use the nationally representative second round of the India Human Development Survey (IHDS) to estimate the effect of early marriage on completed schooling using an instrumental variable strategy and explore the stability of this estimate for κ derived in the first step.[6]

3.1 Estimates of κ from the Young Lives study.

Table 1 describes the relationship between early menarche and completed education.[7] The difference in the completed years of education for the two groups of girls, though not statistically significant, is 0.91 years, that is, those who reached menarche before twelve get 0.91 years less education, on average than other girls in their cohort. We can recover the bounds around the two-stage least squares estimates at this level of κ. I also replicate this specification with district fixed effects instead of sampling site fixed effects, and the difference in the completed education across the two groups of girls is 1.01 years. Finally, the last column presents the results of the effect of being unmarried by eighteen on completed schooling while using the incidence of early menarche to isolate the variation in the timing of marriage. The instrumental variable approach involves estimating a two-stage model which is specified as follows:

$$\text{Second Stage} : YearsSchooling_{id} = \beta \widehat{Unmarriedby}18_{id} + \gamma X_{id} + \eta_d + \epsilon_{id} \tag{3.4.1}$$

$$\text{First Stage} : Unmarriedby18_{id} = \rho EarlyMenarche_{id} + \gamma X_{id} + \eta_d + \mu_{id}, \tag{3.4.2}$$

where $YearsSchooling_{id}$ is the completed years of schooling for woman i in district d, $Unmarriedby18_{id}$ is an indicator equal to one when the woman had not married by eighteen, and $EarlyMenarche_{id}$ is an indicator equal to one if the woman started menstruating before twelve. X_{id} denotes a vector of controls, and η_d denotes district fixed effects.[8] The two-stage least squares estimate is seven years. However, F-statistic from the first stage is only 8.3, and the problem of a weak instrument renders these results not suitable for estimating bounds around the two-stage least squares estimates (Conley, Hansen, and Rossi 2012).[9] Therefore, the following discussion explores the stability of these estimates using a larger nationally representative dataset. Moreover, the IHDS has been used for many applications where age at menarche is used as an instrument for age at marriage to study the effect of the latter on outcomes that may be affected by a woman's education (for instance, Sekhri and Debnath 2014; Chari et al. 2017; Dhamija and Roychowdhury 2020).

5. I used the specification with sampling site fixed effects when examining single differences across girls girls who reached menarche before twelve and others.

6. The second round of the IHDS was conducted in 2011-12. The interviews with ever-married women aged 15-49 collected recall data on age at menarche, years of schooling, and age at first marriage.

7. For the girls who are still enrolled at twenty-two, the completed education is taken to be their current completed education. Since the children have not completed their schooling by the fifth survey round, this difference does not reflect the final difference in the completed education across the two groups of girls. Importantly, this difference is the lower bound on the difference in completed education as more girls in the who had not reached menarche by twelve menarche group are likely to continue education as they are 34% more likely to be in college at twenty-two.

8. Since the other literature using the IHDS data uses district fixed effects, district fixed effects are included.

9. The 95% confidence interval using the union of confidence intervals method is [-6.8, 14.7] and using the local to zero method when it is assumed that κ is drawn from a uniform distribution on the support (-1.01,0) is [-0.8, 13.5].

3.2 Two-stage Least Squares Estimation Using the IHDS Data

The second round of the IHDS was conducted in 2011-12. The interviews with ever-married women aged 15-49 collected recall data on age at menarche, years of schooling, and age at first marriage. As is common for the literature that uses the timing of menarche as an instrument for the timing of marriage, I restrict the sample to women who had not dropped out of school by age ten (Field and Ambrus 2008). In addition, I consider only those women who married after menarche.[10] The distribution of the difference between age at dropout and age at menarche is bimodal, where one of the two peaks is at zero: a substantial mass of girls drop out of school right after menarche (Figure 3).[11] The distribution of the difference between at age at dropout and age at marriage shows that most girls marry about five years after dropping out of school.

For estimating results comparable to the ones described in Table 1, I included control variables that were similar to the set of controls included in that specification. The final set of controls includes current land ownership, current log per-capita consumption, age, age-squared, location of residence (urban or rural), and the number of members in the household. In addition, variables that capture information about the woman's natal home are included: an indicator for if the natal home is economically better off than the marital home, father's education, mother's education, number of brothers, and number of sisters. The IHDS does not contain information about the geographical location of the woman's natal home. To capture her childhood experiences that may be correlated to her schooling, I include district fixed effects.[12] Robust standard errors clustered at the level of a district are reported.

The two-stage least squared estimates show that being unmarried by eighteen increases schooling by 4.6 years (Table 2). The 95% confidence interval estimated using the union of confidence intervals method is [-12.6, 6.1] when κ lies in the support [-1.01,0].[13] To implement the local-to-zero method, it is assumed that κ is drawn from a uniform distribution on the support $(\kappa^L, 0)$. The 95% confidence interval in this case when κ^L is -1.01 is [-9.3, 4.5].

Figure 4 and Figure 5 describe the 95% confidence intervals for different levels of departure from the exclusion restriction. The extent of violation of the exclusion restriction estimated from the Young Lives data is more than three times the maximum allowed violation that would ensure that the bounds do not contain zero. Therefore, the two-stage least squares estimate is not stable to likely violations in the exclusion restriction, even if those are smaller than the estimated violation using the Young Lives study.

10. Twenty-one girls were not enrolled in school at age ten in the Young Lives study. The second restriction is not binding.

11. Since the IHDS does not collect retrospective information on the age at which a woman dropped out, I use the information on completed years schooling and assume that they started school at age six to impute their age at dropout.

12. Bloch, Rao, and Desai (2004) estimate that the average distance from between martial and natal homes is twenty-one miles, and therefore her natal home is likely to fall within the district of current residence.

13. Since the estimated value of κ from the Young Lives Study is -1.01, I take this to be the upper bound of the violation of the exclusion restriction.

4 Discussion

Two results discussed in this note suggest that the timing of menarche may not satisfy the exclusion restriction when used as an instrument for age at marriage, at least in the Indian setting. First, the gap between menarche and marriage has increased over time, confirming that now there is greater temporal scope for menarche to affect other experiences in a young girl's life. In a companion paper, I also show that reaching menarche before age twelve leads to a 14.3% decline in school enrollment rate. Menarche is also affected by the girl's socio-economic environment. Second, the two-stage least squares estimates where early menarche is used to instrument for marriage timing are not stable when strict exogeneity of the instrument is replaced by plausible exogeneity.

While the estimates of the effect of the age at marriage based on an identification strategy that uses menarche for younger Indian cohorts as an instrument are likely biased, whether they are qualitatively useful depends on the context that shapes society's reactions to menarche. An important direction for future work is understanding how menarche affects various experiences in a young girl's life to grasp the information content contained in these estimates fully.

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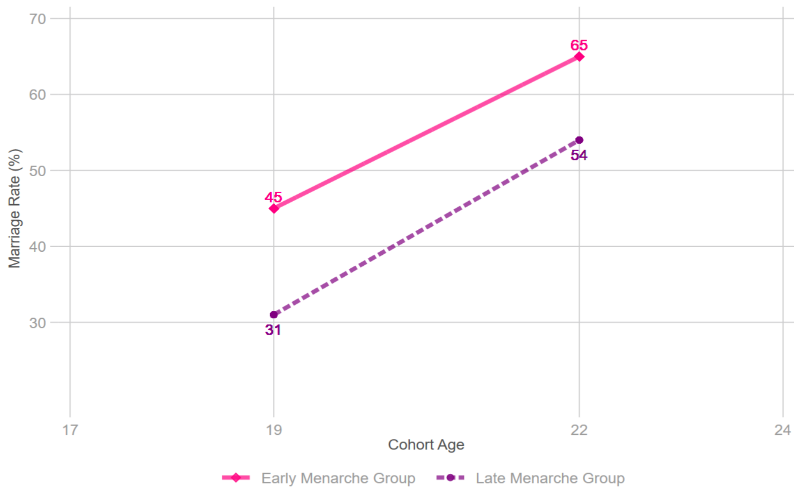
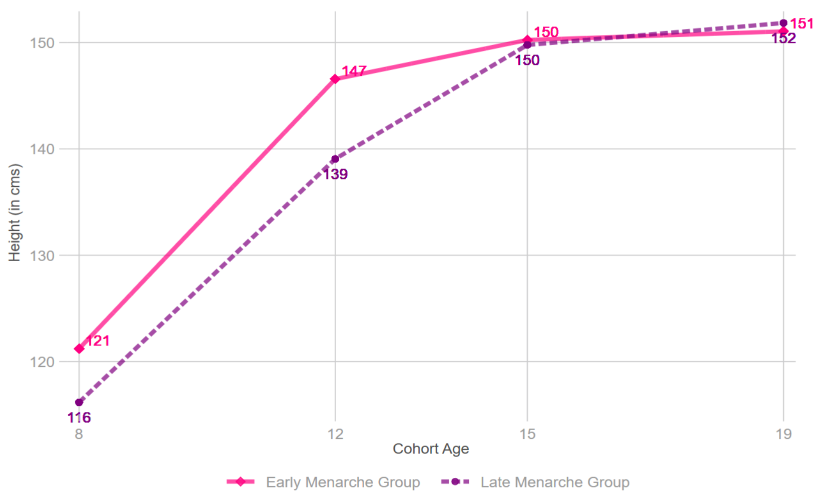
Figures

Figure 1. Marriage Rate by Menarche Status



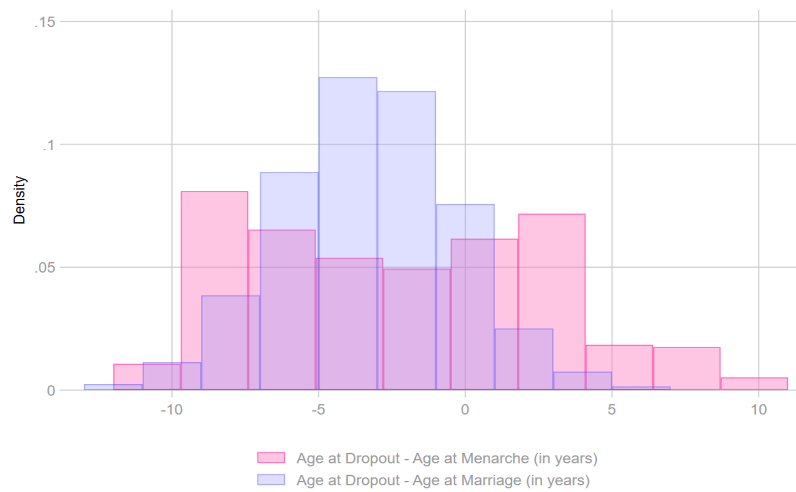
Note: Data are taken from the Young Lives study. The solid (pink) line represents the trends in marriage rate for girls in the early menarche group and the dashed (purple) line represents the trends in marriage rate for girls in the late menarche group. Both the lines describe trends the ages of nineteen and twenty-two.

Figure 2. Height by Menarche Status



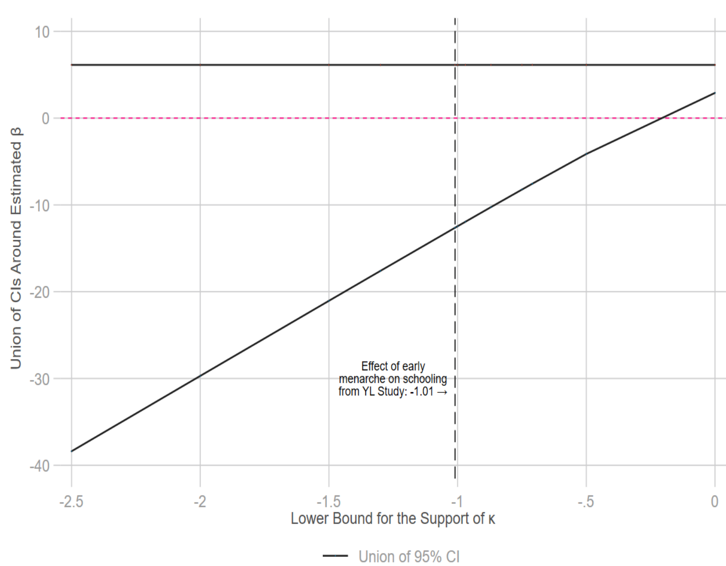
Note: Data are taken from the Young Lives study. The solid (pink) line represents the trends in height (in centimeters) for girls in the early menarche group and the dashed (purple) line represents the trends in height (in centimeters) for girls in the late menarche group.

Figure 3. Age at Marriage, School Dropout and Marriage



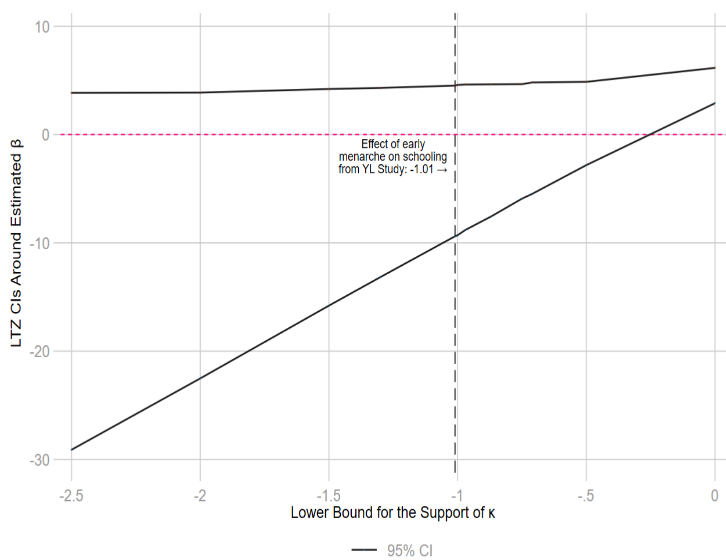
Note: Data are taken from the IHDS. The histogram in the lighter (pink) shade represents the difference between the age at which girls drop out of school and the age at which they reached menarche (in years) and the histogram in the darker (purple) shade represents the difference between the age at which girls drop out of school and the age at which they get married (in years).

Figure 4. 95% CI Around IV Estimates, UCI Method



Note: Data are taken from the IHDS. Grey lines represent the 95% CI derived using the LTZ method.

Figure 5. 95% CI Around IV Estimates, LTZ Method



Note: Data are taken from the IHDS. Grey lines represent the 95% CI derived using the LTZ method.

Tables

Table 1. Menarche and Years of Schooling, Evidence from the YL Study

	(1)	(2)	(3) (OLS)	(4) (2SLS)
Early menarche	-0.910	-1.010*		
	(0.560)	(0.451)		
Unmarried by 18			3.041***	7.041***
			(0.295)	(0.835)
Observations	474	474	474	474
R^2	0.331	0.290	0.407	0.185
Control average	12.75	12.75	12.75	12.75
Sampling site FE	Yes	Yes	Yes	Yes
District FE	No	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Fstat				8.377

Note: Columns (1)-(2) report results from single-difference specification (see Equation 5.3). Controls include household size, caste, sex of the household head, wealth index,mom's literacy status, age of the head of the household, indicator of whether the child speaks the majority language, number of younger siblings, number of older siblings, number of older brothers, number of older sisters, test scores at age eight, weight at age eight, and BMI at age eight. In column (1), sampling site fixed effects are included and standard errors are clustered at the sampling site level. In column (2), district fixed effects are included and standard errors are clustered at the district level. The last two columns present the results on the effect of being unmarried until eighteen on completed schooling using OLS and 2SLS specifications. Estimation is restricted to those who dropped out of school after ten.
* Significant at 10%; ** Significant at 5%; *** Significant at 1%.

Table 2. Menarche and Years of Schooling, Evidence from the IHDS Data

	(1)	(2) OLS	(3) 2SLS
Early Menarche	-0.334***		
	(0.071)		
Single by 19		1.600***	4.604***
		(0.049)	(0.975)
Observations	21591	21591	21591
R^2	0.391	0.440	0.265
Control average	3.907	3.907	3.907
District FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Fstat			42.03

Note: Column (1) report results from single-difference specification (see Equation 5.3). Controls include household size, caste, age, age-squared, log per capita consumption, indicator for land ownership, location (rural or urban), indicator if the natal home if economically better-off, mother's education, father's education, mother's education, number of brothers and number of sisters. District fixed effects are included and standard errors are clustered at the district level. The last two columns present the results on the effect of being unmarried until eighteen on completed schooling using OLS and 2SLS specifications. Estimation is restricted to those who dropped out of school after ten and married after menarche.
* Significant at 10%; ** Significant at 5%; *** Significant at 1%.