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# Maternal Age and Offspring's Educational Attainment

*Using data from the National Longitudinal Study of Adolescent to Adult Health (Add Health), the current study examines which maternal age at birth provides offspring with optimal opportunities for higher educational attainment. The results show that maternal age has a curvilinear relationship with offspring's educational attainment, that is, the offspring of younger and older mothers are distinctly disadvantaged. Maternal ages 31 through 40 are associated with the highest offspring educational attainment, suggesting that women who give birth in their 30s have more favorable characteristics than younger or older mothers. The analysis demonstrates that—with the exception of early teenage childbearing—the association between maternal age and offspring's educational attainment likely reflects selection patterns in fertility timing, rather than direct within-family effects of maternal age on offspring's educational attainment. Thus, the results provide insufficient evidence to conclude that delaying childbearing beyond age 18 directly benefits or harms offspring's educational attainment.*

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A well-established body of literature (e.g., Addo, Sassler, & Williams, 2016; Levine, Emery, & Pollack, 2007; Levine, Pollack, & Comfort, 2001) provides consistent theoretical and empirical support that early childbearing is associated with worse academic outcomes among children. Early childbearing interrupts parents' human capital development and earnings (Diaz & Fiel, 2016; Kane, Morgan, Harris, & Guilkey, 2013) and the accumulation and transmission of economic, social, and cultural capital (Powell, Steelman, & Carini, 2006). The loss of these familial resources reduces offspring's educational attainment (Björklund & Salvanes, 2011). Likewise, Fergusson and Woodward (1999) found that the offspring of mothers younger than age 30 had less supportive, nurturing, and stable households than the children of older mothers. The authors succinctly argued that this phenomenon is part of a selection process; those who give birth at young ages, particularly as adolescents, are likely the "least well equipped for parenting" among their peers (Fergusson & Woodward, 1999, p. 488). This body of literature solely concentrates on early childbearing as a distinctly disadvantaged category of births, ignoring potential negative effects of advanced maternal age.

During the past 4 decades, maternal age at birth for all birth orders has been increasing in the United States (J. A. Martin et al., 2007; J. A. Martin, Hamilton, Osterman, Driscoll, & Mathews, 2017). Research demonstrates that delayed childbearing, especially after age 40, is


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associated with diminished fecundity (Balasch & Gratacós, 2011), and increased incidences of infant mortality and perinatal complications (Jacobsson, Ladfors, & Milsom, 2004). Children born to older mothers who survive past infancy are at greater risk of adverse health outcomes, such as poorer self-rated health, coronary heart disease, diabetes, obesity, cancer, and mortality (Barker, 2002; Johnson et al., 2009; Myrskylä & Fenelon, 2012). Therefore, this rising trend in postponed childbearing may impact the well-being of recent cohorts. Although the association between delayed childbearing and diminished fecundity and (infant and adult) health are well established, it is less clear how advanced maternal age at birth impacts her offspring's academic outcomes.

The positive association between education and individual well-being is well documented, including better physical and mental health outcomes (Hummer & Hernandez, 2013; Lundborg, 2013; Mirowsky & Ross, 2003), relationship stability (i.e., divorce, relationship dissolution; Cherlin, 2010; T. C. Martin & Bumpass, 1989), and inter- and multigenerational socioeconomic mobility (Mare, 2014). Thus, education is a central factor in determining adult well-being. Given the influence of education on life chances and the increasing trend in delayed childbearing, the current study extends the existing literature by examining the association between maternal childbearing age and children's educational attainment. The study makes the following three primary contributions to literature on fertility timing and academic outcomes: (a) identify the best-fitting functional form of the association between maternal age and offspring's educational attainment, (b) estimate the maternal age at birth that provides optimal opportunities for offspring's educational attainment, and (c) advance the discussion on the consequences of childbearing at advanced maternal ages.

## Stratification Within Families, Between Families, or Biological Decline?

The literature outlines the following three explanations for the association between advanced maternal age and offspring's educational attainment: within-family differences in resource allocation, between-family fertility selection processes, and biological decline. The first explanation regards maternal age as a determinant of stratification within the family. Accordingly, women's childbearing age may positively or negatively influence their offspring's opportunities by reducing or increasing the resources they receive in comparison to their siblings. These familial resources could be financial resources, human capital (Becker, 1994), cultural capital (Bourdieu, 1984), and interpersonal resources (Fergusson & Woodward, 1999). Although some researchers propose a negative association between parental age and the familial resources conferred to their children (for a review, see Powell et al., 2006), most studies find a positive relationship. Mare and Tzeng (1989), for example, found that delayed fathering was beneficial for sons' educational attainment but observed diminishing education returns at older ages (i.e., a tailing curvilinear relationship). Powell et al. (2006) found evidence for curvilinear relationships between maternal age and resources conferred to children. Most of these relationships became positive and linear after adjusting for parental socioeconomic status. Furthermore, in a comment on supplementary analyses, Powell et al. (2006) noted that maternal age may have a curvilinear relationship with academic outcomes net of socioeconomic confounders, recommending that future research examine this relationship. Although these studies do not directly examine the relationship between maternal age at birth and offspring's educational attainment, the results suggest the association is positive and linear, with a possibility of a curvilinear relationship.

European literature focused on the possibility of within-family stratification by using sibling fixed effects models to control for between-family differences. Using Dutch survey data for birth cohorts between 1918 and 1974, Kalmijn and Kraaykamp (2005) demonstrated evidence of positive within-family effects of maternal age on offspring's educational attainment. Drawing on Swedish register data for birth cohorts born between 1960 and 1982, Barclay and Myrskylä (2016) observed a similar positive relationship between maternal age and offspring's educational attainment. However, this relationship disappeared after controlling for birth cohort, demonstrating that this relationship was driven by a secular trend in increasing education. It is unlikely that Kalmijn and Kraaykamp's finding of a positive relationship was driven by a secular trend as they controlled for birth cohort trends in tertiary education completion. In short, prior literature provides mixed evidence for maternal age as a within-family determinant of educational attainment, finding positive or no effect of delaying childbearing. Given these discrepancies, our study aims to help clarify these existing findings by using longitudinal data from a U.S. cohort. This within-family hypothesis would be confirmed if we observe a positive relationship between maternal age and offspring's educational attainment when employing a sibling fixed effects model.

Alternatively, maternal age may serve as a marker of between-family stratification, vis-à-vis fertility timing, which highlights differences between mothers as a means of stratification. The between-family hypothesis suggests the possibility of a curvilinear relationship between maternal birth ages and her offspring's educational attainment, noting that women with less socioeconomic resources are overrepresented among younger and older mothers (Powell et al., 2006). Other characteristics of these younger and older mothers may be unobserved, such as—although not limited to—greater propensities toward unintended (mistimed and unwanted) childbearing, which may also reflect women's risk preferences. Illustrating the curvilinear trend in unintended (mistimed and unwanted) childbearing, research shows that the highest rates occur among teens and women in their late 30s and 40s (Cheng, Schwarz, Douglas, & Horon, 2009; Henshaw, 1998). Similarly, high-risk tolerance, which is associated with both early and late fertility timing and unintended fertility, also exhibits a curvilinear trend with women's ages, although this relationship depends on women's education (Schmidt, 2008). Consequently, research indicates that both children from unplanned or unwanted births and children born to risk-tolerant parents have reduced educational attainment (Barber, Axinn, & Thornton, 1999; Brown, Ortiz-Nuñez, & Taylor, 2012; Fergusson & Woodward, 1999). This (negative) fertility timing selection process would mostly occur among biological mothers, as adoptive parenting generally requires planning and large quantities of resources (L. Hamilton, Cheng, & Powell, 2007). These studies therefore suggest that mothers' psycho-social characteristics may selectively drive fertility timing, thereby (indirectly) driving between-family differences in their children's educational achievements. Thus, we anticipate a curvilinear association between maternal age and educational attainment, reflecting the selectivity of younger and older mothers.

The final explanation concerns biological decline at advanced maternal ages. Potentially reflecting declines in fecundity and fertility, advanced maternal age is associated with an increased risk of low birthweight (Khoshnood, Wall, & Lee, 2005), poor health outcomes later in life (Liu, Zhi, & Li, 2011), and cognitive disability (Cohen, 2014) among offspring. In turn, poor pregnancy outcomes can lead to learning disabilities, poor childhood academic performance, and reduced educational attainment (Behrman & Rosenzweig, 2004; Litt, Taylor, Klein, & Hack, 2005). Research shows within-family evidence of reduced adult cognitive ability among the offspring of older mothers, potentially pointing to causal effects of biological decline (Myrskylä, Silventoinen, Tynelius, & Rasmussen, 2013). In contrast, however, research from the United Kingdom did not observe a negative association between advanced maternal age and cognitive ability when controlling for sociodemographic background (Goisis, Schneider, & Myrskylä, 2017). If biological decline is a factor in the association between maternal age and her offspring's educational attainment, we anticipate a negative association between advanced maternal age and educational attainment—even after employing sibling fixed effects models. This relationship would be mediated by factors related to biological aging, such as infant and childhood health, disabilities, or cognitive ability. However, the aforementioned European research disconfirmed evidence of negative effects of advanced maternal age on offspring's educational attainment (Barclay & Myrskylä, 2016; Kalmijn & Kraaykamp, 2005). It is reasonable to extrapolate these findings to the United States because it is unlikely that women in the United States are biologically distinct from Swedish or Dutch women. Thus, the evidence strongly suggests that negative biological influences of advanced maternal age on offspring's educational attainment are unlikely.

## Potential Confounders

There are various potential confounders in the relationship between maternal age at birth and offspring's educational attainment.

For example, birth order and family size are negatively associated with offspring's educational attainment and are positively associated with maternal age. Booth and Kee (2009) found strong evidence for negative effects of increased birth order and family size on offspring's educational attainment, arguing that these associations are due to familial resource dilution. Another example includes when mothers begin childbearing, which is correlated with subsequent births. For example, births before age 25 may be selective of mothers who would also have another child before age 25 (Fergusson & Woodward, 1999). The influence of this early childbearing may be additive, as early childbearing of a respondent's sibling may interrupt their parents' human capital accumulation (Kane et al., 2013) and diminish available resources for the respondent.

Controls for demographic characteristics, such as mother's relationship status and race, are standard inclusions in research on maternal age (Addo et al., 2016; Powell et al., 2006). Mother's relationship status is associated with increased maternal age at birth and greater educational attainment among offspring (Addo et al., 2016; Fergusson & Woodward, 1999). Early childbearing is more common among Black and Hispanic women than among White and Asian women (Sweeney & Raley, 2014), particularly with regard to nonmarital births (B. E. Hamilton, Martin, Osterman, Driscoll, & Rossen, 2017). Simultaneously, Blacks and Hispanics have lower levels of educational attainment, on average, than Whites and Asians (Ryan & Bauman, 2016). Our analyses therefore incorporate controls for these outlined confounders.

## Data and Measures

### *Data*

We used data from Waves 1 (1995) and IV (2007–2008) of the National Longitudinal Study of Adolescent to Adult Health (Add Health; http://www.cpc.unc.edu/projects/addhealth) to examine the relationship between maternal age and offspring's educational attainment. Add Health began with in-school interviews of more than 90,000 participants in Grades 7 to 12 from 80 high schools and 52 middle schools throughout the United States. The in-school interviews were followed by four waves of in-home interviews (a subsample) in 1995 (Grades 7–12), 1996 (Grades 8–12), 2001–2002 (age 18–26), and 2007–2008 (age 24–32, mean of 29). We note that it is unlikely that respondents from Add Health were conceived using artificial reproductive techniques as their birth years range from 1974 through 1983. Use of in vitro fertilization on humans was first performed in 1978 and was in its early days of development in the early 1980s (Johnson-Hanks, Bachrach, Morgan, & Kohler, 2011; Wang & Sauer, 2006).

We limited the data set to respondents who lived with their mother in Wave I ($n = 18{,}397$). We then dropped cases missing information on birth order due to issues with the simultaneous imputation of birth order and family size variables ($n = 18{,}376$). To account for missing cases, we ran 10 rounds of chained multiple imputation on all missing cases. The vast majority of these missing cases were from the income variable (22% missing). We then removed cases missing information on educational attainment in Wave IV ($n = 14{,}072$). Next, we dropped adoptive mothers because we emphasized both the possibility of biological decline at advanced maternal age and fertility timing selection ($n = 13{,}626$). Last, we removed cases missing maternal age at birth ($n = 13{,}539$) and mothers older than age 45 ($n = 13{,}530$). We dropped respondents born to mothers older than age 45 ($n = 9$) because there are not enough cases for a separate category. We did not merge this age group with mothers in their early 40s because vital statistics and public health literature generally separates these age groups (e.g., B. E. Hamilton et al., 2017; Jacobsson et al., 2004). After these restrictions, we had 13,530 complete cases for the regression analyses.

We also included a supplemental analysis using Add Health's sibling file. Consistent with past literature (Barclay & Myrskylä, 2016; Kalmijn & Kraaykamp, 2005), we restricted our analysis to full-biological (non-twin) siblings ($n = 2{,}296$). Beginning with 2,126 linked full siblings living with their biological mother, we dropped respondents who were not living with their sibling pair ($n = 2{,}085$), missing information on birth order ($n = 2{,}084$), missing educational attainment in Wave IV ($n = 1{,}761$), and missing maternal age ($n = 1{,}746$). Due to insufficient numbers of older mothers, we removed all families with births from mothers older than age 40 ($n = 1{,}742$). Thus, this analysis does not pertain to the oldest category of mothers. Last, we removed all sibsets missing a matched sibling, leaving 1,518 complete cases of linked full siblings. We believe that this limited sample is sufficient enough to test within-family hypotheses. Similar to the primary file, we used 10 rounds of multiple imputation to recover missing cases from control variables.

### *Dependent Variable*

Years of education serves as the outcome variable for this article. We used the technique from Kane et al. (2013; available on request) for converting the ordinal variable for educational attainment from Add Health Wave IV to a linear variable. Because the average respondent was in his or her late 20s (mean age 29), we can reasonably assume that the vast majority of individuals have completed their educational attainment.

### *Independent Variable and Control Variables*

Maternal age at time of birth, obtained from the Wave I parent survey, was measured in several forms. First, we used linear, squared, and cubic terms for maternal age, similar to Powell et al. (2006). We dropped cases for those younger than age 15 and older than age 45. Sensitivity analyses suggest that the inclusion of respondents born to mothers ages 13 and 14 did not alter our results. Second, borrowed from Kalmijn and Kraaykamp (2005), maternal age was broken into the following 5-year categories: 15 to 20, 21 to 25, 26 to 30, 31 to 35, 36 to 40 (referent), and 41 to 45. Missing maternal ages due to nonresponse in the parent survey were imputed from the respondent's report of their mother's age.

Because Add Health does not include information on all of a respondent's siblings, we used the household roster from Wave I to measure early maternal childbearing of resident siblings: resident sibling(s) born when mother is age 25 or younger (referent), all resident siblings born after the mother was age 25, and no resident siblings. Addo et al. (2016) suggested that age 25 is approximately the cutpoint for early childbearing, arguing early childbearing may interrupt parental human capital accumulation. Total years passing between the Wave I and the Wave IV interviews were used to calculate respondent's age in Wave IV. We also tested models including dummy variables for respondent's age, akin to those used by Barclay and Myrskylä (2016). We found that the inclusion of age dummy variables did not meaningfully change our results.

Age variables—categorical or linear—can be interpreted as a combination of age and birth cohort effects, which tend to be biased if both age and birth cohorts simultaneously share a positive relationship with educational attainment. Researchers have yet to establish a satisfactory methodological solution that can adjudicate between age, period, and cohort effects (e.g., Bell & Jones, 2014; Luo, 2013). However, this issue is less concerning in our models because we examined educational attainment among a relatively small birth cohort (10 cohorts total), whereas studies such as Barclay and Myrskylä (2016) analyzed 22 birth cohorts and thus had more potential bias from secular education trends. Furthermore, excluding age from our models did not substantially change the results, suggesting limited bias from age and cohort effects.

Birth order and family size (*sibsize*), coded as dummy variables, were obtained from Wave I. First birth order and family size of one were selected as the reference groups. Both variables were top coded at 10. Although recent economic research (e.g., Booth & Kee, 2009) on the relationship between birth order and family size and educational attainment used continuous distributions for these variables (including the construction of birth order index by family size), we used dummy variables to more completely account for differences in education by birth order.

Our models controlled for maternal relationship status and respondent's race or ethnicity from Wave I. Maternal relationship status was broken into one of the following three categories: married (referent), like married (cohabiting or living with a romantic partner), and single. Race or ethnicity was broken into the following five categories: non-Hispanic White (referent; hereafter "White"), non-Hispanic Black (hereafter "Black"), Hispanic, non-Hispanic Asian or Pacific Islander (hereafter "Asian"), and non-Hispanic other (hereafter "other").

Last, we controlled for parental socioeconomic status: education, occupation, and income. Obtained from the parent survey, parental education was measured as the highest level of educational attainment between the mother and her resident partner (usually father). Missing cases from the parent survey were imputed from the respondent's report. Parental occupation was measured as the highest level of occupation between the mother and her resident partner. Add Health's measures of occupation have no clear rank order. Thus, we dichotomized parental occupation: professional or manager and nonprofessional or manager (referent). Income, obtained from the parent survey, had a high rate of missing cases (22%) from nonresponse in the parent survey. We applied a natural log to this variable to account for skewness.

## Methods

The following is our list of proposed models examining the association between maternal age and offspring's educational attainment:

$$\text{Education Years} = \alpha + \beta_1 \text{ age} + \varepsilon \quad (1)$$

$$\text{Education Years} = \alpha + \beta_1 \text{age} + \beta_2 \text{age}^2 + \varepsilon \quad (2)$$

$$\text{Education Years} = \alpha + \beta_1 \text{age} + \beta_2 \text{age}^2 + \beta_3 \text{age}^3 + \varepsilon \quad (3)$$

$$\text{Education Years} = \alpha + \beta_1 \text{age} + \beta_2 \text{age}^2 + \beta_3 \text{age}^3 + \beta_4 \mathbf{X} + \varepsilon \quad (4)$$

$$\text{Education Years} = \alpha + \beta_1 \text{age} + \beta_2 \text{age}^2 + \beta_3 \text{age}^3 + \beta_4 \text{ed} + \beta_5 \mathbf{X} + \varepsilon \quad (5)$$

$$\text{Education Years} = \alpha + \beta_1 \text{age} + \beta_2 \text{age}^2 + \beta_3 \text{age}^3 + \beta_4 \text{ed} + \beta_5 \text{occ} + \beta_6 \text{inc} + \beta_7 \mathbf{X} + \varepsilon \quad (6)$$

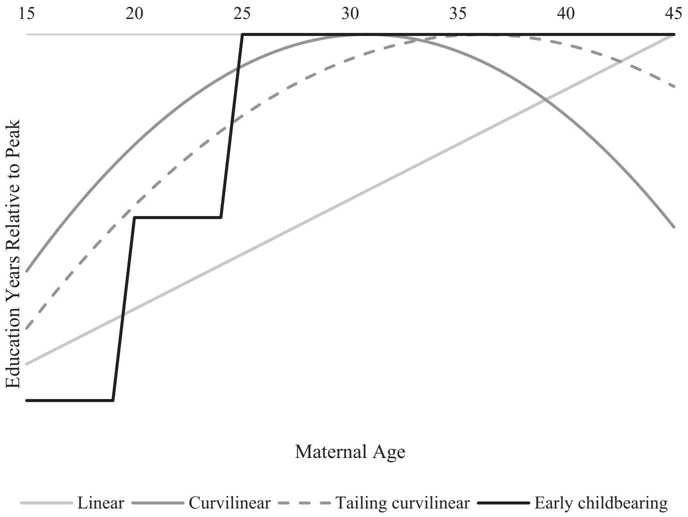
$$\text{Education Years} = \alpha + \beta_1 \text{agecat} + \beta_2 \text{ed} + \beta_3 \text{occ} + \beta_4 5\text{inc} + \beta_5 \mathbf{X} + \varepsilon \quad (7)$$

Model 1 includes a linear scoring of maternal age that produces an equal and incremental increase or decrease in offspring's educational attainment. Model 2 adds a quadratic term for maternal age, allowing the estimated association to be curvilinear. Model 3 includes a cubed age term, which allows for more flexibility or detail in the curvilinear relationship. Prior to introducing control variables, we expected this relationship to be curvilinear, aligning with findings from the bivariate models of Powell et al. (2006).

Model 4 includes a matrix of control variables for birth order of the respondent, family size, maternal relationship status, respondent's age in Wave IV, race or ethnicity, and early maternal childbearing of siblings. Model 5 adds a covariate for parental education, and Model 6 adds variables for parental occupation and income. If this curvilinear relationship is due to socioeconomic characteristics, the squared or cubed terms for maternal age may become statistically nonsignificant in these models. This finding—of a positive relationship—would align with the argument of Powell et al. (2006) that maternal age is associated with increased family resources conferred to offspring when controlling for family background. In turn, these resources could lead to increased educational attainment among offspring. Alternatively, models including socioeconomic control variables may feature a tailing curvilinear relationship (see Figure 1), indicating that there are diminishing returns, but no substantial negative effects, of delayed childbearing (for similar findings on paternal age, see Mare & Tzeng, 1989).

Model 7 replaces the continuous age variables with dummy variables for maternal age. This representation allows for both unconstrained effects of age and assesses prior constraints, serving as a robustness check for the polynomial models. In addition, this model allowed us to more rigorously test if negative associations between maternal age and offspring's educational attainment are only observed in instances of early childbearing (Addo et al., 2016). In sum, these models tested different functional forms of maternal age and estimate the maternal age that offers her offspring optimal educational attainment. We approximated these anticipated associations between maternal age and offspring's educational attainment identified by previous studies in Figure 1. We note that the cross-sectional models cannot directly test the between- and within-family hypotheses, necessitating the use of sibling fixed effects models (see later). Furthermore, although the biological decline hypothesis is unlikely, we tested this hypothesis by estimating a model with proposed cognitive and infant or childhood health mechanisms in our robustness tests.

FIGURE 1. PROPOSED RELATIONSHIPS BETWEEN MATERNAL AGE AND EDUCATIONAL ATTAINMENT.




*Note*. We conceptualize our results as education years by maternal age relative to the peak in education years (i.e., the maternal age at birth that provides optimal opportunities for offspring's educational attainment). For example, the curvilinear model suggests that educational attainment is highest among mothers in their early 30s. All other results are calculated in reference to this peak.

Regression results for polynomial function models (Models 1 to 6) are visually displayed as predicted values of offspring's educational attainment. The peak predicted educational attainment is set to zero in visualizations. For curvilinear relationships, this peak is also the inflection point. Consequently, these figures present the association between maternal age and offspring's educational attainment relative to the optimal maternal age. We refer to these values as predicted education years relative to the peak by maternal age. Information from these models (Models 1 to 6) and the dummy variable model (Model 7) are displayed in table format (see Table 1). Likelihood ratio tests (Table 2) were applied to examine the statistical fit of the nested models. The likelihood ratio test does not allow for multiple imputed data, thus requiring listwise deletion for these models. All of the results in the listwise deleted models were consistent in direction, significance, and magnitude with models using multiple imputation. Survey weights were not used to preserve statistical power. Empirical tests revealed that eschewing survey weights does not substantively bias our results (see Robustness Tests).

We directly examined the within- versus between-family hypotheses by estimating sibling fixed effects models (Table 3). Our pooled sibling model estimated the relationship between maternal age and offspring's educational attainment among *i*, individuals, within *j*, families, such that

$$\text{Education Years}_{\text{ij}} = \alpha + \beta_1 \text{age}_{\text{ij}} + \beta_2 \text{ed}_{\text{j}} + \beta_3 \text{occ}_{\text{j}} + \beta_4 \text{inc}_{\text{j}} + \beta_5 \mathbf{X}_{\text{ij}} + \beta_6 \mathbf{X}_{\text{j}} + \varepsilon_{\text{ij}}$$

We then introduced sibling fixed effects, $\alpha_{\text{j}}$, which controlled for family-level differences. This addition led to the ejection of family-invariant factors from the model, such that

$$\text{Education Years}_{\text{ij}} = \alpha_{\text{j}} + \beta_1 \text{age}_{\text{ij}} + \beta_2 \mathbf{X}_{\text{ij}} + \varepsilon_{\text{ij}}$$

where only independent variables for maternal age and known determinants of within-family stratification—that is, birth order and respondent's age—are included. Thus, these fixed effects models estimated within-family effects. We also estimated equivalent pooled sibling and sibling fixed effects models with squared and cubed functions for maternal age. If the association between maternal age and offspring's educational attainment is no longer significant

Table 1. *Ordinary Least Squares Regression of Education on Maternal Age and Select Covariates Displayed as Unstandardized Coefficients (N = 13,530)*

| Predictors | Model 1 $\beta$ (*SE*) | Model 2 $\beta$ (*SE*) | Model 3 $\beta$ (*SE*) | Model 4 $\beta$ (*SE*) | Model 5 $\beta$ (*SE*) | Model 6 $\beta$ (*SE*) | Model 7 $\beta$ (*SE*) |
|---|---|---|---|---|---|---|---|
| Maternal age (36–40) | | | | | | | |
| 15–20 | | | | | | | $-1.01^{***}$ |
| | | | | | | | (0.14) |
| 21–25 | | | | | | | $-0.71^{***}$ |
| | | | | | | | (0.13) |
| 26–30 | | | | | | | $-0.34^{***}$ |
| | | | | | | | (0.13) |
| 31–35 | | | | | | | −0.14 |
| | | | | | | | (0.13) |
| 41–45 | | | | | | | $-0.71^{*}$ |
| | | | | | | | (0.28) |
| Maternal age | $0.10^{***}$ | $0.53^{***}$ | −0.23 | $-0.36^{*}$ | −0.26 | −0.23 | |
| | (0.00) | (0.03) | (0.18) | (0.18) | (0.17) | (0.17) | |
| (Maternal age)$^2$ | | $-0.01^{***}$ | $0.02^{**}$ | $0.02^{***}$ | $0.02^{*}$ | $0.01^{*}$ | |
| | | (0.00) | (0.01) | (0.01) | (0.01) | (0.01) | |
| (Maternal age)$^3$ | | | $-0.00^{***}$ | $-0.00^{***}$ | $-0.00^{**}$ | $-0.00^{**}$ | |
| | | | (0.00) | (0.00) | (0.00) | (0.00) | |
| $R^2$ | 0.043 | 0.053 | 0.054 | 0.103 | 0.194 | 0.219 | 0.218 |
| $F$ | $562.90^{***}$ | $369.43^{***}$ | $252.75^{***}$ | $51.17^{***}$ | $95.24^{***}$ | $103.42^{***}$ | $97.42^{***}$ |

*Note*. Models 1 to 3 are bivariate models. Model 4 adjusts for respondent age, early maternal childbearing of siblings, maternal marital status, birth order, and family size. Model 5 adds a covariate for parental educational attainment. Models 6 and 7 include additional terms for parental occupation and income. $R^2$ statistics are obtained from listwise deleted models (see Table 2).

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

Table 2. *Likelihood Ratio Tests (N = 9,980)*

| Model Comparisons | Likelihood Ratio Statistic |
|---|---|
| (1) Model 1 & Model 2 | $109.91^{***}$ |
| (2) Model 2 & Model 3 | $12.19^{**}$ |
| (3) Model 3 & Model 4 | $521.28^{***}$ |
| (4) Model 4 & Model 5 | $1,066.00^{***}$ |
| (5) Model 5 & Model 6 | $314.15^{***}$ |

*Note*. To perform the likelihood ratio tests, we estimate models using listwise deletion to remove missing cases rather than applying multiple imputation. All coefficients from these models demonstrate the same direction and significance as equivalent models from Table 1. There is no likelihood ratio test for Model 7 because it uses a categorical term for maternal age; the earlier models use polynomial terms for maternal age. Thus, these earlier models are not nested within Model 7.

$*p < .05$, $**p < .01$, $***p < .001$.

on the inclusion of sibling fixed effects, the between-family hypothesis would be supported over the within-family hypothesis. Lack of older mothers limited our ability to fully assess the biological decline hypothesis, however. In addition, this modeling approach is not designed to capture the dynamic effects of early childbearing on entire sibships via maternal socioeconomic status. These limitations are further explained in the Discussion section. Descriptive information from the sibling file is available upon request.

## Results

### *Descriptive Results*

Table 4 provides unweighted descriptive information for key variables. Mean educational attainment among offspring was 14.4 years. A small percentage of these offspring completed less than a high school degree (8%). A fourth of these offspring completed only a high school degree. The plurality (34%) of offspring completed some college by Wave IV. A large percentage of offspring completed bachelor's degrees (20%), of which a substantial percentage (13%) earned postgraduate degrees.

Table 3. *Full-Sibling Models: Pooled Sibling and Sibling Fixed Effects Regression for Education Regressed on Maternal Age and Other Covariates Displayed as Unstandardized Coefficients (N = 1,518)*

| Predictors | Model 1 β (SE) | Model 2 β (SE) | Model 3 β (SE) | Model 4 β (SE) | Model 5 β (SE) | Model 6 β (SE) | Model 7 β (SE) | Model 8 β (SE) |
|---|---|---|---|---|---|---|---|---|
| Maternal age | 0.06*** | 0.30** | 0.10 | | 0.05 | 0.17 | 2.30* | |
| | (0.02) | (0.11) | (0.54) | | (0.04) | (0.23) | (0.95) | |
| (Maternal age)$^2$ | | −0.00* | 0.00 | | | −0.00 | −0.09* | |
| | | (0.00) | (0.02) | | | (0.00) | (0.04) | |
| (Maternal age)$^3$ | | | −0.00 | | | | 0.00* | |
| | | | (0.00) | | | | (0.00) | |
| Maternal age (20–35) | | | | | | | | |
| <18 | | | | −0.83** | | | | −1.08* |
| | | | | (0.31) | | | | (0.43) |
| 18–19 | | | | −0.13 | | | | −0.17 |
| | | | | (0.20) | | | | (0.25) |
| 36–40 | | | | −0.02 | | | | 0.23 |
| | | | | (0.35) | | | | (0.75) |
| $R^2$ | 0.244 | 0.246 | 0.246 | 0.240 | 0.024 | 0.024 | 0.029 | 0.029 |
| *F* | 17.21*** | 16.76*** | 16.20*** | 15.71*** | 3.29** | 2.92* | 2.90* | 3.03** |
| Estimator | OLS | OLS | OLS | OLS | FE | FE | FE | FE |

*Note*. *N* for families = 728. Models 1 through 4 include the same control variables as Models 6 and 7 in Table 1. Models 5 through 8 only include control variables for sources of within-family variation, birth order, and respondent's age. All models use robust standard errors to account for correlation between siblings. $R^2$ statistics were acquired from models that remove missing cases using listwise deletion. In contrast with the models from the primary analysis (see Table 1), we only include five categories for birth order (1 through 5+) due to small cell sizes for high birth orders. OLS = ordinary least squares; FE = fixed effects.

*$p < .05$, **$p < .01$, ***$p < .001$.

One in five mothers (20%) gave birth between ages 15 and 20. The plurality of mothers (35%) gave birth between ages 21 and 25. Childbearing slowly declined during the life course, with 29% giving birth between ages 26 through 30, and 13% giving birth between ages 31 and 35. Small percentages of mothers gave birth between ages 36 through 40 (3%) and ages 41 through 45 (1%). The average maternal age at birth was at age 25.3.

A considerable percentage of mothers gave birth to other children (than the respondent) when they were 25 years of age or younger (33%). The majority of mothers, however, gave birth to the respondent's siblings when older than the age of 25 (49%). Eighteen percent had no resident siblings. Around half of the respondents were first births, and the plurality of the respondents had a family size of 2. The average respondent was age 29 in Wave IV.

### *Multivariate Results*

Figure 2 provides predicted values from models (1–3) of polynomial functions of maternal age. Model 1 displays a linear increase in educational attainment with increases in maternal age. Including a squared term for maternal age (Model 2), the relationship between maternal age and offspring's educational attainment became curvilinear with an inflection point at age 33. Results from a likelihood ratio test (1; see Table 2) suggest that Model 2 provided improved fit relative to Model 1. Including a cubic term for maternal age in Model 3 produced a curvilinear relationship with the same inflection point as Model 2 (age 33), but featured a considerably steeper decline in education at advanced maternal ages. This model found that children's educational attainment was 1.83 years lower when mothers were age 18 at birth relative to mothers who were age 33 at birth. This disparity became much smaller by age 25, showing a 0.66-year deficit. Similarly, offspring of older mothers were severely disadvantaged. The offspring of mothers ages 40 to 45 lost between 0.80 and 2.58 years of educational attainment relative to offspring born to mothers who were age 33, respectively. The likelihood ratio test (2; see Table 2) suggests that Model 3 had superior

Table 4. *Descriptive Statistics From National Longitudinal Study of Adolescent to Adult Health, Waves I and IV (*N = *13,530)*

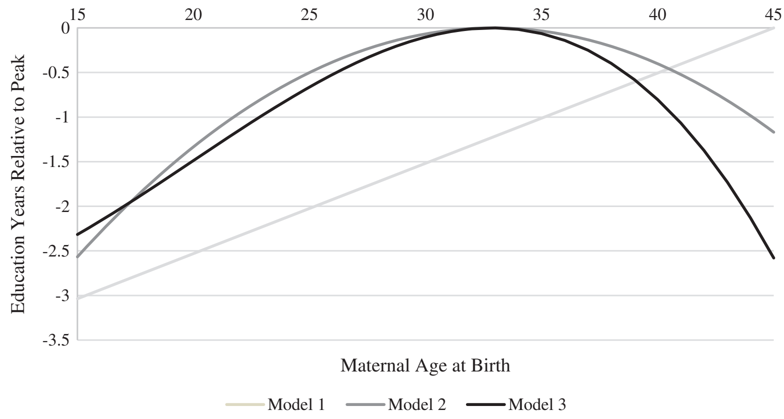
| Variable | *M* (*SD*) | Percentage |
|---|---|---|
| Education in years | 14.43 (2.68) | |
| Education | | |
| <HS | | 8 |
| HS | | 25 |
| Some college | | 34 |
| Bachelor's | | 20 |
| >Bachelor's | | 13 |
| Maternal age at birth | 25.28 (5.29) | |
| Maternal age at birth categories | | |
| 15–20 | | 20 |
| 21–25 | | 35 |
| 26–30 | | 29 |
| 31–35 | | 13 |
| 36–40 | | 3 |
| 41+ | | 1 |
| Early childbearing for siblings | | |
| 25 or younger | | 33 |
| 26+ | | 49 |
| No siblings | | 18 |
| Respondent age in Wave IV | 29.04 (1.74) | |
| Birth order | | |
| 1 | | 49 |
| 2 | | 30 |
| 3 | | 13 |
| 4 | | 5 |
| 5 | | 1 |
| 6 | | 1 |
| 7 | | 0 |
| 8 | | 0 |
| 9 | | 0 |
| 10 | | 0 |
| Family size | | |
| 1 | | 18 |
| 2 | | 36 |
| 3 | | 25 |
| 4 | | 12 |
| 5 | | 4 |
| 6 | | 2 |
| 7 | | 1 |
| 8 | | 0 |
| 9 | | 0 |
| 10 | | 0 |
| Parent's education | | |
| <HS | | 13 |
| HS | | 34 |
| Some college | | 20 |
| Bachelor's | | 19 |
| >Bachelor's | | 14 |
| Mother's relationship status | | |
| Married | | 71 |
| Marriage-like | | 6 |
| Single | | 23 |
| Race | | |
| White | | 56 |
| Black | | 21 |
| Hispanic | | 15 |
| Asian | | 6 |
| Other | | 2 |
| Parent's occupation (professional/manager) | | 35 |
| Parent's income (1000s) | 46.39 (49.91) | |

*Note*. HS = high school.

fit when compared with Model 2. These models suggest that maternal childbearing ages share a curvilinear relationship with offspring's educational attainment, largely consistent with the bivariate findings of Powell et al. (2006) for the relationship between maternal age and family resource transmission.

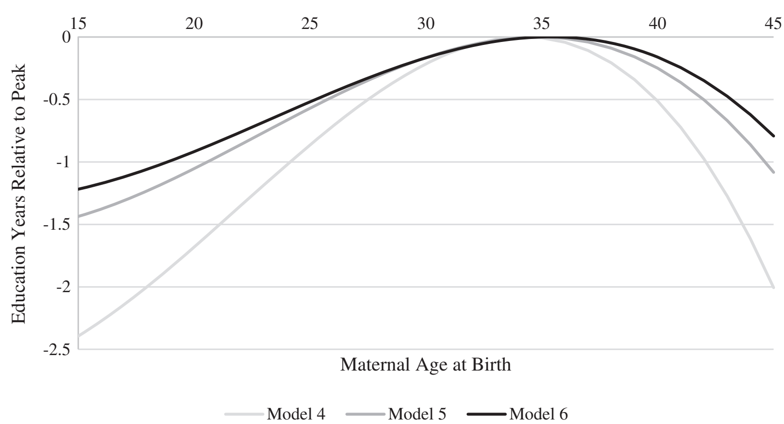
Figure 3 displays changes in predicted educational attainment of offspring controlling for parental socioeconomic status. Model 4 included additional covariates for birth order, family size, maternal relationship status, early childbearing for sibling, respondent age, and respondent race and ethnicity. This model featured a similar curvilinear relationship between maternal age and offspring's educational attainment observed in Model 3, with an inflection point at age 34. This model exhibited improved fit relative to Model 3 (see Tables 1 and 2). The addition of parental education in Model 5 flattened the relationship between maternal age and offspring's educational attainment and offered substantial improvement in statistical fit ($R^2 = 0.194$) from Model 4 ($R^2 = 0.103$; see Table 1). The likelihood ratio test (4; see Table 2) between Models 4 and 5 demonstrated that Model 5 had drastically improved model fit. Model 6 added covariates for parental occupation and income. However, the addition of covariates for occupation and income did not substantially attenuate the curvilinear relationship between maternal age and offspring's educational attainment, displaying a similar inflection point at age 35. In Model 6, the offspring of mothers age 18 at birth lost 1.06 education years relative to those born

FIGURE 2. EDUCATION YEARS BY MATERNAL AGE: ORDINARY LEAST SQUARES MODELS OF DIFFERENT POLYNOMIAL FUNCTIONS ($N = 13{,}530$).




*Note*. Models 1 to 3 are bivariate models. Model 1 uses a linear term for maternal age. Model 2 adds a squared term for maternal age. Model 3 adds a cubed term for maternal age. Further information on models is available in Table 1. Predicted education years are calculated in reference to the peak in education years by maternal age. For example, Model 3's peak in educational years is at age 33. All predicted values of education years are subtracted from the predicted value from this age.

FIGURE 3. EDUCATION YEARS BY MATERNAL AGE: ORDINARY LEAST SQUARES MODELS ADJUSTING FOR PARENTAL SOCIOECONOMIC STATUS ($N = 13{,}530$).




*Note.* $N = 13{,}530$. All models employ a cubic function for maternal age at birth. Model 4 includes variables for respondent age, early maternal childbearing of siblings, maternal marital status, birth order, and family size. Model 5 includes an additional covariate for parental education. Model 6 adds covariates for parental occupation and income. Further information on models is available in Table 1. Predicted education years are calculated in reference to the peak in education years by maternal age. For example, Model 3's peak in educational years is at age 35. All predicted values of education years are subtracted from the predicted value from this age.

to mothers at age 35, whereas the offspring of mothers age 45 lost 0.79 education years. Model 6 demonstrated improved fit relative to Model 5 (likelihood ratio test 5). In summary, increases in maternal ages 15 to 35 were associated with gradual increases in her offspring's educational attainment. The benefits of delaying child-bearing diminish in her mid-30s, however. At age 35, this relationship changed direction and became negative. This negative relationship between advanced maternal age and offspring's educational attainment was considerably sharper than the relationship between early childbearing and offspring's educational attainment, particularly after age 40. Overall, these models suggest that childbearing in women's mid-30s provided optimal opportunities for offspring's educational attainment.

Table 1 provides estimates from our final model (Model 7), which replaced the polynomial variables for maternal age with dummy variables. This model included all covariates used in Model 6. Model 7 found further evidence of a curvilinear relationship between maternal age and offspring's educational attainment. Unlike Addo et al. (2016), we found that the negative influences of early childbearing stretch to age 30. In addition, instead of a linear relationship suggested by Addo et al. (2016), Fergusson and Woodward (1999), and Powell et al. (2006), we found a curvilinear relationship, demonstrating substantially reduced educational attainment for offspring of mothers ages 41 through 45 at birth in comparison with women aged 36 to 40 at birth. This association with offspring's education (−0.71 years) was identical in magnitude to the coefficient associated with ages 21 through 25 (−0.71). Model 7 therefore suggested that childbearing at maternal ages 31 through 40 was optimal for offspring's educational attainment. Fit statistics suggested that Model 6 ($R^2 = 0.219$) and 7 ($R^2 = 0.218$) had similar statistical fit (a likelihood ratio test could not be performed because these models were not nested).

Next, we used data from Add Health's linked full siblings to differentiate within- and between-family associations that confound the relationship between maternal age and offspring's educational attainment (see Table 3). Models 1, 2, and 3 are pooled sibling models, which revealed similar patterns to those observed in the primary analysis (see Table 1). The absence of mothers older than age 40, however, was likely responsible for the nonsignificance of the cubed term (Model 3). Fixed effects models (Models 5 and 6), which used linear and squared terms for maternal age, found no significant relationship between maternal age and offspring's educational attainment. However, the addition of a cubic term (Model 7) revealed a significant relationship between maternal age and offspring's educational attainment. Additional models using a categorical measure of maternal age (see Models 4 and 8) revealed that this relationship was driven by negative effects of childbearing before age 18—childbearing at ages 18 and 19 did not have a negative effect on offspring's educational attainment. This suggests that the residual association in the fixed effects models was merely the product of the relationship between early teenage childbearing and offspring's educational attainment. Analyses using alternative categorizations of maternal age (see Appendix Table A5) confirmed our findings of a curvilinear relationship in ordinary least squares models and a null relationship—aside from early teenage childbearing—in fixed effects models. Early teenage childbearing was relatively uncommon; only 4% of respondents in the sibling file and 5% of the respondents in the cross-sectional files were born to mothers younger than age 18. In short, these results disconfirmed the existence of a universal, positive within-family relationship between maternal age and offspring's educational attainment, as indicated by our evidence for within-family (negative) effects of early teenage childbearing on offspring's educational attainment.

In summary, the cross-sectional results demonstrated that the relationship between maternal age and offspring's educational attainment was curvilinear, indicating that childbearing when women were in their 30s offers optimal opportunities for offspring's educational attainment. In addition, these models provided evidence against distinct negative influences of early childbearing. Sensitivity analyses found that these results remain consistent whether respondents completed their education or were currently enrolled (not shown). Controlling for cognitive ability, birthweight, adolescent health, and learning disability did not alter the observed relationship between maternal age and offspring's educational attainment (not shown), further weakening explanations concerning biological decline. Moreover, the results from the Add Health sibling file suggested that the observed relationship between maternal age and offspring's educational attainment was driven primarily by between-family, rather than within-family, associations. It is important to note, however, that we observed a large within-family effect of teenage childbearing before age 18 on offspring's educational attainment. This suggested that maternal age did not directly influence offspring's educational attainment, with the exception of the negative effects of early teenage childbearing.

## Extension, Replication, and Robustness Tests

### *Adoptive Mothers*

We performed additional analyses to test both the within- and between-family hypotheses, in addition to replicating our findings using data from another comparable longitudinal study (see online appendix for results). Specifically, we employed models that (a) only used information from adoptive mothers and (b) combined information from biological and adoptive mothers using Add Health data. Our adoptive mother models found no association between maternal age and offspring's educational attainment. Models that combined biological and adoptive mothers had modestly weakened associations between maternal age and educational attainment, remaining consistent with adoptive mother models. The 26-through-30 age category was no longer significantly different from the 36-through-40 category in the pooled model. The lack of an association between the age of mothers at the time of adoption with offspring's educational attainment suggested that the maternal age and offspring education relationship was limited to biological mothers. This finding suggested that intendedness of birth—which was not a factor for adoptive mothers—was a plausible mechanism for the observed relationship between maternal age and offspring's educational attainment.

### *Replication in the National Education Longitudinal Study (NELS)*

Last, to examine the external validity of our main findings, we replicated our analysis using NELS. The NELS models ($N = 11{,}728$) produced an almost identical relationship between maternal age at birth and her offspring's educational attainment to those found in our primary analyses using Add Health. The association was clearly curvilinear with an optimal age of 36 through 40, demonstrating the substantial disadvantages of early and late childbearing on offspring's educational attainment.

Our replication in NELS demonstrated that the associations found in this study did not empirically conflict with those from the prior study from Powell et al. (2006) on maternal age and resource transfers, which also used data from NELS for their analysis. Nevertheless, Powell et al. (2006) proposed that increased family resources associated with delayed childbearing may influence adolescents' quality of life, regardless of their impact on educational attainment.

### *Robustness Tests*

First, we tested the necessity of using Add Health's survey weights using weight association tests described by Bollen et al. (2016) and by directly comparing point estimates from unweighted and weighted models. Survey weights diminish statistical power and are often unnecessary with the proper use of control variables. As Bollen et al. (2016) specified, we only performed this test on maternal age because it was the only variable of substantive interest. Although our tests revealed evidence of minor bias in coefficients, comparisons between unweighted and weighted models revealed little to no substantive difference in the results (see Appendix Figure A10). Moreover, these assessments demonstrated the robustness of our main finding, which was an inverse U-shaped relationship between maternal age and offspring's educational attainment. Weighting tests on the NELS data also showed no evidence of substantial bias.

In addition to assessing model sensitivity using survey weights, we estimated models using alternative categorizations of offspring's educational attainment. These models confirmed findings from the primary analysis. We also estimated ordinal probit models using the five-category measure of education seen in Table 4 and an alternative 10-category measure. These models found strong evidence for an inverse U-shaped relationship between maternal age and offspring's educational attainment that peaks in the mid-30s and suggested that childbearing at ages 31 through 40 was optimal for offspring's educational attainment, consistent with our ordinary least squares models used in the primary analysis. Reestimating our models using robust standard errors to account for heteroskedasticity also produced nearly identical results. Sensitivity analyses using school fixed effects—rather than sibling fixed effects—suggested that the negative relationship between early childbearing and educational attainment might be modestly attenuated by accounting for residential selection. However, consistent with the overall magnitude, direction, and statistical significance observed in our primary analysis, the school fixed effects model found negative associations between advanced maternal age (41–45) and offspring's educational attainment.

Furthermore, models examining alternative categorizations of maternal age were consistent with Model 7 (see Table 1). Testing additional nonlinear forms of maternal age (i.e., 1/x and square root of x) did not improve empirical fit to the hypothesized model. Although small cell-size may cause some instability in this model, including mothers between ages 46 to 50 in the model as a separate category showed that offspring of these mothers achieved even lower years of educational attainment than the children of mothers age 41 through 45 at birth. Our results also remained unchanged when excluding mothers who did not self-report their age at birth, suggesting that our measure of maternal age has negligible measurement error. We also estimated birth order–stratified models and found no meaningful evidence that the relationship between maternal age and offspring's educational attainment varied by birth order.

Last, we tested the biological decline hypothesis by including variables for cognitive score, adolescent self-rated health, birthweight, and reported learning disabilities. Providing further evidence for a curvilinear relationship between maternal age and offspring's educational attainment, these additions had no meaningful influence on the association between advanced maternal age and offspring's educational attainment. Models including both cognitive score and high school GPA somewhat mediated the negative association between early childbearing and offspring's educational attainment. We also tested parental death as a mechanism (Myrskylä & Fenelon, 2012) and found that it slightly attenuated the association between advanced maternal age and offspring's educational attainment. We also examined interactions between maternal age and race or ethnicity to test the weathering hypothesis (Geronimus, 1992). These models found no evidence of weathering effects on Black respondents. Overall, these tests provided evidence against the biological decline hypothesis. Apart from early teenage childbearing, our sensitivity analyses suggested that the association between maternal age and her offspring's educational attainment appeared to be driven by between-family selection processes.

## Discussion

Apart from births to women younger than age 18, our study found strong evidence that maternal age at birth is likely a between-family marker of social stratification rather than a within-family determinant of offspring's educational attainment. The curvilinear relationship we observed is consistent with selective patterns in fertility timing, such as birth intendedness (Cheng et al., 2009; Henshaw, 1998) and risk preferences (Schmidt, 2008). Our findings are also largely consistent with findings from recent European research (Barclay & Myrskylä, 2016), which observed no within-family effect of maternal age on offspring's educational attainment. In addition, our analyses along with past literature (Barclay & Myrskylä, 2016; Kalmijn & Kraaykamp, 2005) suggest that this pattern was not driven by biological decline at advanced maternal ages. Thus, we posit that broader structural barriers may disproportionately select younger and older mothers into circumstances that confer disadvantages to their offspring in the form of educational attainment, relative to the offspring born to women who give birth in their 30s. The offspring born to women in their 30s reap the benefits of this selection pattern, obtaining more years of education than their peers born to younger or older women.

Although the within-family hypothesis was disconfirmed for maternal ages 18 and older, we found that the children born to women younger than age 18 obtain fewer years of education than their siblings born at older maternal ages. This within-family effect is consistent with some prior research on teenage childbearing, which observed uniquely negative associations between early teenage childbearing and offspring's academic outcomes (e.g., Cooksey, 1997; Levine et al., 2007). Consistent with previous literature, we postulate that the children of young teenage mothers receive fewer family resources than their siblings born at older maternal ages, which in turn, negatively impacts their educational attainment. Our findings may suggest optimism about the future consequences of the continued decline in early teenage childbearing in the United States (J. A. Martin et al., 2017) for overall levels of educational attainment.

Furthermore, our findings suggest that future research would benefit from an increased focus on the heterogeneity among women who give birth at ages older than 40. It is likely that selection into older childbearing is changing over time with increasing rates of first births older than age 40 (Goisis et al., 2017; Mathews & Hamilton, 2014). If the negative association between late childbearing and offspring's educational attainment is solely driven by negative selection processes, we may continue to see increasing trends of negative outcomes among children born to older mothers. Conversely, the growing use of in vitro fertilization may lead individuals to plan around late childbearing, despite its reduced success rates at older ages (Leridon, 2004). In vitro fertilization births, unlike other births to older mothers, cannot be the product of unintended pregnancy, and thus substantially alter this selection process. Although this population—of births to older women—is small in percentage, it increasingly constitutes a large constituency of births (J. A. Martin et al., 2017; Mathews & Hamilton, 2014), and thus merits attention from research.

### *Limitations*

It is important to note a few limitations of our study. First, our analyses were limited by small sample sizes among mothers age 41 through 45 at birth (1%). However, our replication in NELS suggested that this finding is robust and not idiosyncratic to Add Health. Second, although our analyses extensively examined the association between maternal age and her child's educational attainment, the observed associations are not causal relationships. Third, we were unable to examine the influences of maternal childbearing ages on the educational attainment of entire sibships. This would require data with complete sibships, such as those found in European registers. Fourth, our sibling fixed effects models were limited in their ability to test the biological decline hypothesis. If the negative effect of advanced maternal age on offspring's educational attainment operates similarly to its association with fecundity or infant health—a linear decline that becomes noticeable around age 35 (Balasch & Gratacós, 2011)—our models should capture this effect. However, the sibling model would be unable to capture a biological decline that begins at age 40 or later. Future studies should extend our analyses by examining a larger sample of older mothers. Last, sibling fixed effects models are limited by the variation in educational attainment among siblings. Other recent studies using identical (monozygotic-MZ) twin fixed effects models with similar sample sizes ($n = 671$ to 2,819) to rule out a causal relationship (or suggest that these effects are not meaningful) between educational attainment (predictor) and several health indicators (outcome; Amin, Behrman, & Kohler, 2015) had substantially less variation in educational attainment than our full-sibling models. Furthermore, our models possessed the variation to detect a significant association between birth order and educational attainment. This suggests that our models had sufficient statistical power for examining the relationship between maternal childbearing ages and offspring's educational attainment. Therefore, we believe the findings from our study provide strong evidence against the existence of a meaningful within-family relationship between maternal age and offspring's educational attainment, aside from early teenage childbearing.

### *Conclusion*

In short, our results demonstrated that fertility timing is a highly selective process that has a strong association with offspring's social mobility. Upon further analysis, we found that—with the exception of early teenage childbearing—fertility timing does not impact offspring's educational attainment. Rather, childbearing at young and old ages is likely selective of women who face structural barriers, which may confer disadvantages to their children. Future research should therefore examine between-family factors as potential determinants of both fertility timing and their offspring's educational attainment. In addition, the persistent negative within-family effect of early teenage childbearing observed in our sibling fixed effects models provides evidence for an important within-family mechanism that may disadvantage families. In contrast with findings from Powell et al. (2006) on family resource transmission, however, we contend that maternal childbearing age—beyond age 18—is not a major determinant of her offspring's educational attainment. Instead, the inclusion of maternal age as a control variable in educational attainment models may approximate potential confounding factors associated with parental selection.

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## Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Appendix S1. Supporting information

## References

Addo, F. R., Sassler, S., & Williams, K. (2016). Reexamining the association of maternal age and marital status at first birth with youth educational attainment. *Journal of Marriage and Family*, *78*, 1252–1268. https://doi.org/10.1111/jomf.12360

Amin, V., Behrman, J. R., & Kohler, H.-P. (2015). Schooling has smaller or insignificant effects on adult health in the US than suggested by cross-sectional associations: New estimates using relatively large samples of identical twins. *Social Science & Medicine*, *127*, 181–189. https://doi.org/10.1016/j.socscimed.2014.07.065

Balasch, J., & Gratacós, E. (2011). Delayed childbearing: Effects on fertility and the outcome of pregnancy. *Fetal Diagnosis and Therapy*, *29*(4), 263–273. https://doi.org/10.1159/000323142

Barber, J. S., Axinn, W. G., & Thornton, A. (1999). Unwanted childbearing, health, and mother-child relationships. *Journal of Health and Social Behavior*, *40*(3), 231–257.

Barclay, K., & Myrskylä, M. (2016). Advanced maternal age and offspring outcomes: Reproductive aging and counterbalancing period trends. *Population and Development Review*, *42*, 69–94. https://doi.org/10.1111/j.1728-4457.2016.00105.x

Barker, D. J. (2002). Fetal programming of coronary heart disease. *Trends in Endocrinology & Metabolism*, *13*(9), 364–368. https://doi.org/10.1016/S1043-2760(02)00689-6

Becker, G. S. (1994). *Human capital: A theoretical and empirical analysis, with special reference to education* (3rd ed.). Chicago: The University of Chicago Press.

Behrman, J. R., & Rosenzweig, M. R. (2004). Returns to birthweight. *Review of Economics and Statistics*, *86*(2), 586–601. https://doi.org/10.1162/003465304323031139

Bell, A., & Jones, K. (2014). Another "futile quest"? A simulation study of Yang and Land's Hierarchical Age-Period-Cohort model. *Demographic Research*, *30*, 333. https://doi.org/10.4054/DemRes.2013.30.11

Björklund, A., & Salvanes, K. G. (2011). Education and family background: Mechanisms and policies. In E. A. Hanushek, S. Machin, & L. Woessmann (Eds.), *Handbook of the economics of education* (Vol. 3, pp. 201–247). Amsterdam, Netherlands: North Holland.

Bollen, K. A., Biemer, P. P., Karr, A. F., Tueller, S., & Berzofsky, M. E. (2016). Are survey weights needed? A review of diagnostic tests in regression analysis. *Annual Review of Statistics and Its Application*, *3*, 375–392. https://doi.org/10.1146/annurev-statistics-011516-012958

Booth, A. L., & Kee, H. J. (2009). Birth order matters: the effect of family size and birth order on educational attainment. *Journal of Population Economics*, *22*(2), 367–397. https://doi.org/10.1007/s00148-007-0181-4

Bourdieu, P. (1984). *Distinction: A social critique of the judgement of taste*. Cambridge: Harvard University Press.

Brown, S., Ortiz-Nuñez, A., & Taylor, K. (2012). Parental risk attitudes and children's academic test scores: Evidence from the US panel study of income dynamics. *Scottish Journal of Political Economy*, *59*, 47–70. https://doi.org/10.1111/j.1467-9485.2011.00568.x

Cheng, D., Schwarz, E. B., Douglas, E., & Horon, I. (2009). Unintended pregnancy and associated maternal preconception, prenatal and postpartum behaviors. *Contraception*, *79*(3), 194–198. https://doi.org/10.1016/j.contraception.2008.09.009

Cherlin, A. J. (2010). Demographic trends in the United States: A review of research in the 2000s. *Journal of Marriage and Family*, *72*, 403–419. https://doi.org/10.1111/j.1741-3737.2010.00710.x

Cohen, P. N. (2014). Parental age and cognitive disability among children in the United States. *Sociological Science*, *1*, 102–110. https://doi.org/10.15195/v1.a8

Cooksey, E. C. (1997). Consequences of young mothers' marital histories for children's cognitive development. *Journal of Marriage and the Family*, *59*(2), 245–261. https://doi.org/10.2307/353468

Diaz, C. J., & Fiel, J. E. (2016). The effect (s) of teen pregnancy: Reconciling theory, methods, and findings. *Demography*, *53*(1), 85–116. https://doi.org/10.1007/s13524-015-0446-6

Fergusson, D. M., & Woodward, L. J. (1999). Maternal age and educational and psychosocial outcomes in early adulthood. *Journal of Child Psychology and Psychiatry*, *40*, 479–489. https://doi.org/0021-9630/99

Geronimus, A. T. (1992). Teenage childbearing and social disadvantage: Unprotected discourse. *Family Relations*, *41*, 244–248. https://doi.org/10.2307/584840

Goisis, A., Schneider, D. C., & Myrskylä, M. (2017). The reversing association between advanced maternal age and child cognitive ability: Evidence from three UK birth cohorts. *International Journal of Epidemiology*, *46*(3), 1–10.

Hamilton, B. E., Martin, J. A., Osterman, M. J., Driscoll, A. K., & Rossen, L. M. (2017). *Births: Provisional data for 2016* (Vital Statistics Rapid Release No. 002). Atlanta: Centers for Disease Control and Prevention.

Hamilton, L., Cheng, S., & Powell, B. (2007). Adoptive parents, adaptive parents: Evaluating the importance of biological ties for parental investment. *American Sociological Review*, *72*, 95–116. https://doi.org/10.1177/000312240707200105

Henshaw, S. K. (1998). Unintended pregnancy in the United States. *Family Planning Perspectives*, *30*(1), 24–46. https://doi.org/10.2307/2991522

Hummer, R. A., & Hernandez, E. M. (2013). The effect of educational attainment on adult mortality in the United States. *Population Bulletin*, *68*(1), 1–16.

Jacobsson, B., Ladfors, L., & Milsom, I. (2004). Advanced maternal age and adverse perinatal outcome. *Obstetrics & Gynecology*, *104*(4), 727–733. https://doi.org/10.1097/01.AOG.0000140682.63746.be

Johnson, K. J., Carozza, S. E., Chow, E. J., Fox, E. E., Horel, S., McLaughlin, C. C., … Von Behren, J. (2009). Parental age and risk of childhood cancer: A pooled analysis. *Epidemiology*, *20*(4), 475. https://doi.org/10.1097/EDE.0b013e3181a5a332

Johnson-Hanks, J. A., Bachrach, C. A., Morgan, S. P., & Kohler, H.-P. (2011). *Understanding family change and variation: Toward a theory of conjunctural action* (Vol. 5). New York: Springer.

Kalmijn, M., & Kraaykamp, G. (2005). Late or later? A sibling analysis of the effect of maternal age on children's schooling. *Social Science Research*, *34*(3), 634–650. https://doi.org/10.1016/j.ssresearch.2004.04.008

Kane, J. B., Morgan, S. P., Harris, K. M., & Guilkey, D. K. (2013). The educational consequences of teen childbearing. *Demography*, *50*(6), 2129–2150. https://doi.org/10.1007/s13524-013-0238-9

Khoshnood, B., Wall, S., & Lee, K. (2005). Risk of low birth weight associated with advanced maternal age among four ethnic groups in the United States. *Maternal and Child Health Journal*, *9*, 3–9. https://doi.org/10.1007/s10995-005-2446-4

Leridon, H. (2004). Can assisted reproduction technology compensate for the natural decline in fertility with age? A model assessment. *Human Reproduction*, *19*(7), 1548–1553. https://doi.org/10.1093/humrep/deh304

Levine, J. A., Emery, C. R., & Pollack, H. (2007). The well-being of children born to teen mothers. *Journal of Marriage and Family*, *69*, 105–122. https://doi.org/10.1111/j.1741-3737.2006.00348.x

Levine, J. A., Pollack, H., & Comfort, M. E. (2001). Academic and behavioral outcomes among the children of young mothers. *Journal of Marriage and Family*, *63*, 355–369. https://doi.org/10.1111/j.1741-3737.2001.00355.x

Litt, J., Taylor, H. G., Klein, N., & Hack, M. (2005). Learning disabilities in children with very low birthweight: Prevalence, neuropsychological correlates, and educational interventions. *Journal of Learning Disabilities*, *38*(2), 130–141. https://doi.org/10.1177/00222194050380020301

Liu, Y., Zhi, M., & Li, X. (2011). Parental age and characteristics of the offspring. *Ageing Research Reviews*, *10*(1), 115–123. https://doi.org/10.1016/j.arr.2010.09.004

Lundborg, P. (2013). The health returns to schooling—What can we learn from twins? *Journal of Population Economics*, *26*(2), 673–701. https://doi.org/10.1007/s00148-012-0429-5

Luo, L. (2013). Assessing validity and application scope of the intrinsic estimator approach to the age-period-cohort problem. *Demography*, *50*(6), 1945–1967. https://doi.org/10.1007/s13524-013-0243-z

Mare, R. D., & Tzeng, M.-S. (1989). Fathers' ages and the social stratification of sons. *American Journal of Sociology*, *95*(1), 108–131.

Mare, R. D. (2014). Multigenerational aspects of social stratification: Issues for further research. *Research in Social Stratification and Mobility*, *35*, 121–128. https://doi.org/10.1016/j.rssm.2014.01.004

Martin, J. A., Hamilton, B. E., Osterman, M., Driscoll, A. K., & Mathews, T. (2017). Births: Final data for 2015. *National Vital Statistics Reports: From* *the Centers for Disease Control and Prevention, National Center for Health Statistics, National Vital Statistics System*, *66*(1), 1–70.

Martin, J. A., Hamilton, B. E., Sutton, P. D., Ventura, S. J., Menacker, F., Kirmeyer, S., & Munson, M. L. (2007). Births: Final data for 2005. *National Vital Statistics Reports*, *56*(6), 1–103.

Martin, T. C., & Bumpass, L. L. (1989). Recent trends in marital disruption. *Demography*, *26*(1), 37–51.

Mathews, T., & Hamilton, B. E. (2014). *First births to older women continue to rise* (National Center for Health Statistics Data Brief No. 152). Atlanta: Centers for Disease Control and Prevention.

Mirowsky, J., & Ross, C. E. (2003). *Social causes of psychological distress* (2nd ed.). New York: Routledge.

Myrskylä, M., & Fenelon, A. (2012). Maternal age and offspring adult health: Evidence from the health and retirement study. *Demography*, *49*(4), 1231–1257. https://doi.org/10.1007/s13524-012-0132-x

Myrskylä, M., Silventoinen, K., Tynelius, P., & Rasmussen, F. (2013). Is later better or worse? Association of advanced parental age with offspring cognitive ability among half a million young Swedish men. *American Journal of Epidemiology*, *177*(7), 649–655. https://doi.org/10.1093/aje/kws237

Powell, B., Steelman, L. C., & Carini, R. M. (2006). Advancing age, advantaged youth: Parental age and the transmission of resources to children. *Social Forces*, *84*(3), 1359–1390. https://doi.org/10.1353/sof.2006.0064

Ryan, C. L., & Bauman, K. (2016). *Educational attainment in the United States: 2015*. Suitland, MD: US Census Bureau.

Schmidt, L. (2008). Risk preferences and the timing of marriage and childbearing. *Demography*, *45*(2), 439–460.

Sweeney, M. M., & Raley, R. K. (2014). Race, ethnicity, and the changing context of childbearing in the United States. *Annual Review of Sociology*, *40*, 539. https://doi.org/10.1146/annurev-soc-071913-043342

Wang, J., & Sauer, M. V. (2006). In vitro fertilization (IVF): A review of 3 decades of clinical innovation and technological advancement. *Therapeutics and Clinical Risk Management*, *2*(4), 355–364.