The Effect of Maternal Education on Child Health

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Abstract

We use an IV approach to examine the causal effect of mother's high school education on child health using the 1979-2002 waves of the NLSY79 and the 1990-2002 waves of the NLSY79CY. We instrument education with a rich set of education policy variables. We find that mothers who complete high school are more likely to report their child was ill enough to need a doctor, that their child was ill more times, and that their child was more likely to have fractured or dislocated a bone in the past 12 months that required medical attention or treatment. Across samples of mothers who dropped out of high school and who completed high school, we find no difference in the date of their children's last routine health checkup, percentiles for weight-for-age, height-for-age, BMI-for-age, or in the probability of children at risk of overweight and of being overweight. When we examined the possible mechanisms, we found that mother's high school education increases mother's age at child's birth, health insurance coverage and child care use. We also find suggestive evidence of a much more complex set of behaviors that are causally related to education (child care use, health insurance status, fertility decisions) and that likely affect child health. This preliminary evidence suggests that much more work needs to be done before one can strongly conclude that child health does or does not systematically vary with differences in maternal education on the margin we study.

1. Introduction and Background

Scientists and policy makers have long been interested in the theoretical and empirical relationship between education and social and economic outcomes not directly tied to labor markets. Among other outcomes of interest, empirical researchers have studied not only whether a person improves her own health when she gets more education but also whether the health of her children improves (Grossman and Kaestner 1997; Grossman 2005). Although researchers long ago developed theoretical models of household and health production functions that include a role for education (Becker 1960; Grossman 1972), the empirical literature has yielded a limited and conflicting body of evidence on the causal effect of education on health.

The body of empirical evidence is yet unsettled in part because theory suggests not only that education can improve health but also that health can affect education. This simultaneous causal relationship has meant that empirical studies must find a way to separate the causal effect of health on education from the causal effect of education on health. In addition to potential problems of simultaneity, investigations of the causal role of education on health must confront classical omitted variable bias – the usual candidates being unobserved ability (Behrman and Rosenzweig 2002) and rates of time preference (Fuchs 1982, de Walque 2004, 2005). To confront these empirical challenges researchers have used three methods: the inclusion of past health measures (Wagstaff 1993, Bolin et al 2002, Hurd and Kapteyn 2003); exploiting differences between siblings or twins (Wolfe and Behrman 1987, Strauss 1990, Behrman and Rosenzweig 1999); and the method of instrumental variables (IV) (Berger and Leigh 1989; Currie and Moretti 2003; Kenkel, Lillard and Mathios 2006). Of these, the IV approach imposes the fewest assumptions and has produced the most reliable estimates (Grossman, 2005).

IV studies of outcomes in developing economies generally find that education is

associated with better child health. Using variation in education that resulted from the construction of new primary schools and other education policy changes, researchers find that, when women get more education, child mortality falls (Breierova and Duflo 2004; Blunch 2005) and children's height-for-age increases (Ahmad and Iqbal 2005).

IV studies using US data yield more mixed evidence. Using variation in education that resulted when colleges were opened nearby, Currie and Moretti (2003) find that white women who got more education had healthier children. However, McCrary and Royer (2006) find that women with an additional year of education below high school (predicted from the interaction between compulsory schooling laws and dates of birth), gave birth to children whose health did not differ from children born to women with fewer years of education. Limitations in both studies leave open the question of whether more educated US women produce healthier children.

In both the developing and developed economy context, a better understanding of the causal relationship between education and health is a key input to several ongoing public policy debates because it affects estimates of the public and private benefits of education. Knowing whether and how education affects the production of health – especially the health of children - will affect not only decisions about the public financing of education but also decisions about how to target and deliver health inputs. Although several researchers are focused on whether education affects health input delivery in the developing world context (Schultz 1993; Strauss 1990), the issue figures as prominently in debates about public health of children in more developed economies (Currie and Moretti 2003; McCrary and Royer 2006).

In this study we follow a well-established literature that uses the IV approach to contribute in several ways to a sparser set of studies that use US data to investigate whether a child's health improves when his mother gets more education. Like several recent studies, we

use state education policies as instruments that likely satisfy the exogeneity assumption required by the IV method.[1] In particular, like Kenkel, Lillard, and Mathios (2006), we use high school graduation requirements and policies governing testing for and issuance of certificates of General Educational Development (GED). We also exploit aspects of compulsory education laws similar to those used by Adams (2002), Lleras-Muney (2005), Chevalier (2004), Black, Devereux, and Salvanes (2004), Arendt (2005), and McCrary and Royer (2006).[2] What distinguishes our set of instruments from those used in other studies is that, because we have exact dates of changes in education policies, we exploit the full variation in these laws.[3]

Our study also contributes because it uses nationally representative data from the 1979-2002 waves of the National Longitudinal Survey of Youth 1979 (NLSY79) and the 1990-2002 waves of the NLSY79 Child and Young Adult Surveys (NLSY79CY). These data allow us to investigate the effect of a mother's high school education on her child's health for women of all races and across a wide range of ages. Our results therefore complement the results of Currie and Moretti (2003) who, because so few black women attended and completed college during their sample period, could only use their instrument for a sample of white mothers. Because we examine birth outcomes of women as old as 40, our study extends the analysis of McCrary and

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[1] An older literature uses instruments with questionable exclusion restrictions because they are the outcome of individual or parental choices. These instruments have included parental schooling (Berger and Leigh 1989; Sander 1995a, 1995b; Leigh and Dhir 1997), ability test scores, scores on tests of knowledge about occupations (Berger and Leigh 1989), number of siblings (Sander 1995a, 1995b), and parental income (Leigh and Dhir 1997). A second set of instruments, slightly less questionable because they reflect choices families made in the more distant past, includes whether a family lives in a rural area, region of residence at age 16 (Sander 1995a, 1995b), and state of residence in childhood (Leigh and Dhir 1997).

[2] Other instruments used in the more recent literature include per capita state income, education spending in one's childhood state of residence (Berger and Leigh 1989), child labor laws, and state characteristics at age 14 (Lleras-Muney 2005, Adams 2002), college openings (Currie and Moretti 2003); primary school construction programs (Chou, Grossman, and Liu 2003, Breierova and Duflo 2004); and Vietnam War draft induction risk (DeWalque 2004, MacInnis 2006).

[3] Except for Kenkel, Lillard, and Mathios (2006), who also use exact dates of changes, previous studies rely on snapshots of a few provisions of compulsory education laws compiled every several years. They assign the same laws to all children in the same cohort (Acemoglu and Angrist 2000, Lleras-Muney 2005, Lochner and Moretti 2004).

Royer (2006) - who limit their sample to mothers aged 23 or younger – to a broader population.

Finally, to the best of our knowledge, ours is the first study to examine whether completing high school education affects child health not only in infancy but also through childhood and into adolescence. Our preliminary results indicate that the causal relationship between a child's health and whether his mother completes high school is a complicated is either unaffected or worse when his mother completed high school compared to when she drops out.

The remainder of the paper proceeds as follows. In section 2 we sketch the basic model and conceptual framework underlying the study. In section 3 we outline the identification strategy. We describe the data in section 4. We present results from the main analysis in section 5 and results from a set of robustness checks in section 6. In section 7 we discuss the results, conclude, and discuss what our results imply for future research.

2. Basic Model and Conceptual Framework

Researchers have incorporated a causal role for education in theoretical health production and health demand models in two ways. A number of researchers have posited that more educated mothers might produce better health because they combine health inputs more efficiently (Rosenzweig and Schultz 1982, Rosenzweig and Schultz 1989, Kenkel 1991, Kenkel 2000, Rosenzweig 1995, Goldman and Lakdawalla 2002, Glied and Lleras-Muney 2003). For example, more educated mothers may buy the optimal amount of preventative care by visiting doctors at a rate that more effectively prevents serious illnesses. Similarly, when they have children, more educated women may consciously consume less of goods, such as tobacco or alcohol, because the negative externalities associated with the consumption of those goods raises what it costs to produce a healthy child. This causal pathway has been given the label "allocative efficiency." Other researchers have posited that education directly affects the amount of health a

woman can produce with a given set of inputs (Grossman 1972a, 1972b, 2000). A more educated woman might produce more health from a given set of inputs if, for example, her education taught her what combinations of food yield the most nutrients. Similarly, more educated women might produce more health from given inputs because their education makes it more likely that they carefully follow the treatment plan that doctors prescribe. This causal pathway has been given the label "productive efficiency."

These two pathways are easily incorporated into extensions of Grossman's (1972) health production model used by Blunch (2005), Gilleskie and Harrison (1998) and Kennedy (2003). We follow those authors by assuming that each mother's utility (U) depends on her own consumption (X) and the health of her child (H). That is $U = u(X, H)$ (1). A child's health (H) is produced with purchased (medical) inputs (M) (including the time of others), and a mother's time (T_c) and it varies systematically with age (A), and unobserved characteristics (η). We include a mother's education (E) in the health production function to reflect its "productive efficiency" in the production of health (i.e. it shifts the health production function). The formal relationship is given by: $H = h(M, T_c; E, A, \eta)$ (2) where variables before the semicolon are choice variables and those after the semicolon are predetermined.

Mothers are constrained in the time they can invest and the amount of money they have to purchase inputs. All available time (normalized to 1) is spent either investing in her child's health or working (T_w). The time constraint is given by: $1 = T_c + T_w$ (3).

A woman earns a wage W that depends on her education (E) so that W=W(E). All earnings are spent buying goods she consumes and medical inputs. That is the budget constraint is given by: $T_w W(E) = P_x X + P_m M$ (4) where P_x is the price of consumption, and P_m is the price of medical inputs.

A mother chooses the time she devotes to her child's health production, the amount of purchased medical inputs, and her own consumption to maximize (1) subject to (2)-(4). Solving the model yields first-order conditions that show the standard result – she allocates time to production of child health, consumes, and buys medical inputs until the ratio of marginal utility of each pair of choices just equals the ratio of the price of those inputs. That is, she allocates resources to satisfy: $\dfrac{U_H H_T}{U_x} = \dfrac{W(E)}{P_x}$ (5), $\dfrac{U_H H_M}{U_x} = \dfrac{P_M}{P_x}$ (6), and $\dfrac{H_T}{H_M} = \dfrac{W(E)}{P_M}$ (7)

where U_i and H_i denotes the partial derivatives of the utility and health production functions with respect to the corresponding argument. (5)-(7) imply that women with more education invest less of their own time into the production of their child's health because they earn more in the labor market. They therefore rationally buy more medical inputs.

Of course this simple model fails to include other possible channels through which education may affect child health input allocation. For example, the model does not include a the possibility that more educated women may get access to more resources because they are able to marry higher quality spouses. We also do not model how education alters fertility decisions (directly or through income effects) as in quantity-quality models of fertility which suggests that the changes in income induces a shift in mother's preference from quantity to quality of children (Becker 1960, Becker 1991, Becker and Lewis 1973, Behrman and Rosenzweig 2002, Angrist, Lavy and Schlosser 2005). In those models, women with more education want fewer but higher quality children because the opportunity cost of her time increases as her education increases.

The empirical work that follows is generally guided by the above model but, for now, we have only crude empirical counterparts to proxy for purchased inputs and no measure of time

inputs. In the future, however, we will examine some of the pathways, such as the use of prenatal care, cigarette use, alcohol consumption, etc.

3. Identification strategy

The effect of mother's education on child health is estimated using an IV approach. In the first stage, we estimate mother's education using state's education policies as instruments:

$$E = \alpha_0 + \alpha_1 IV + \varepsilon \qquad (8)$$

where E is mother's education (an indicator variable for high school completion or more) and IV is a vector of state policy variables that capture the state's compulsory education environment including: including: the minimum age of compulsory entry, the minimum age of permitted school leaving, the difference in the cutoff month for school entry and child's birth month (i.e. cutoff month minus birth month), interaction of this difference with the minimum age of compulsory entry, the difference in the child's birth month from June (i.e. counting back from June), interaction of this difference with the minimum age of permitted school leaving, total number of courses required for high school graduation, an indicator variable for states that do not set a statewide minimum number of courses for high school graduation, first factor calculated from factor analysis using the number of academic courses required for high school graduation,[4] first factor obtained from factor analysis using the number of elective courses required for high school graduation, an indicator variable for states that do not set a statewide minimum number of courses for high school graduation, an indicator variable for mothers whose compulsory school entry policies were assigned assuming that she lived in the same state as her first reported state of residence, and an indicator variable for mothers whose compulsory school entry policies were

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[4] Our intention here is to generate variation in the probability of completing high school rather than to gauge the effect of the specific policies. However, it should be kept in mind that the instruments we use could capture differences in both the quality and quantity of education because one of them captures changes in the composition of required courses.

assigned assuming that she lived in the same state as her first reported state of residence.[5] We merge our data with the instruments using mother's state of residence, date of birth and relevant year. The algorithm used to assign the instruments to the mothers is explained in the appendix. The source of identification is variation in the compulsory schooling laws across states over time and across mothers born in different months within a given year that is uncorrelated with children's health.

In the second stage, we estimate the effect of mother's education on child health using her predicted education from (8) and other exogenous variables:

$$H = \beta_0 + \beta_1 \hat{E} + \beta_1 C + \beta_2 S + \varepsilon \qquad (9)$$

where H is one of the several infant health outcomes including: an indicator variable for whether the last checkup was 1 year ago or more, an indicator variable for whether the child had any illness that required medical attention or treatment in past 12 months, the number of illnesses requiring medial attention or treatment in past 12 months, an indicator variable for whether the child had any fractured or dislocated bones that required medical attention or treatment in past 12 months, percentile for height-for-age, percentile for weight-for-age, percentile for body mass index-for-age, an indicator for whether the child is at risk of overweight, and an indicator for whether the child is overweight.[6] $\hat{E}$ is mother's predicted education. C is a vector of child and mother's characteristics including: child's sex, race, age, family size, number of siblings, and

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[5] In NLSY79 geographic code data, all mothers have information on: state of birth, state of residence at age 14, state of residence at the time of interview and several variables on the past several interstate moves. We used the algorithm used in Lillard and Molloy (2006) to assign state of residence for each year since birth for each mother. However, for mothers with missing information on either state of birth or state of residence at age 14 or both, our algorithm does not work. For these mothers, we assumed that she lived in the same state as the state she first reported as her state of residence. For details on the algorithm used to determine mother's state of residence, refer to Lillard and Molloy (2006).

[6] We used percentile for body mass index-for-age to define at risk of overweight (85th percentile and above) and overweight (95th percentile and above).

mother's age and marital status. One must keep in mind that some of these control variables such as mother's age and marital status could themselves be causally affected by education and therefore part of the effect of maternal education could be acting through the coefficients of these variables. We discuss more about this issue later in the paper. S is a vector of characteristics of the child's state of residence when the child health measures were taken including: the ratio of employed men to women; the seasonally-adjusted unemployment rate; real median wages; the maximum value of the federal and state EITC for a single mother with two children; the income eligibility limit for Medicaid eligibility for pregnant women; the annual employment growth rate; and the amount of federal housing money spent per 1,000 residents in the state; and a vector of characteristics of the mother's state of residence when she was affected by compulsory school leaving laws including: personal income, per capita personal income, average earning from industries, construction, manufacturing and service, a vector of characteristics of the child's county of residence when the child health measures were taken including: total active non-federal MDs, total patient care by non-fed MDs, total number of hospitals, and total number of hospital admissions and total number of hospital beds. These variables capture state by year differences that may otherwise be confounded with the variation in state educational policies. Finally, ε is the error term that captures the remaining unobserved factors that are not captured in the equation.

Equations (8) and (9) are estimated using a linear probability model for dummy dependent variables and a simple linear model for continuous dependent variables. While the use of linear probability model will produce inefficient coefficient estimates because the error term is not normally distributed for categorical dependent variables, Greene (1993) suggests that estimates from linear models are generally similar to those produced by nonlinear models when

evaluated at the sample means. Also, Angrist (2001) suggests that the use of linear probability models in the first stage do not produce fundamentally different results as the use of nonlinear probability models in the first stage. The equations are clustered at the state level (i.e. mother's state of residence when she was affected by school exit laws). We include fixed effects for mother's state of residence when she is affected by school entry policies.

4. Data

The data for this study comes from the 1979-2002 waves of the National Longitudinal Survey of Youth 1979 (NLSY79) and 1990-2002 waves of the NLSY79 Child and Young Adult (NLSY79CY). The NLSY79 is a nationally representative dataset that consists of 12,686 individuals who were ages 14-21 as of December 31, 1978. They have been interviewed annually from 1979 to 1994 and biennially since 1994. In 1986, a survey of children born to female NLSY79 respondents began and has been conducted biannually since then. In 1994, information on children ages 15 and older was collected separately and has been conducted biannually since then. The NLSY79CY includes several details of child's current health conditions and health history, from mostly mother's reports for younger children and from self reports for older children. The only child health measures that were partly measured by survey staff are weight and height information. In our sample, 33.9%, 38.1%, 51.4% and 47.2% of the percentile for weight-for-age, percentile for height-for-age, percentile for weight-for-height and obesity measures (percentile for body mass index-for-age, an indicator for whether the child is at risk of overweight, and an indicator for whether the child is overweight) were calculated using measured height and weight information.

Data on state education policies regarding compulsory education laws on school entry and school exit, collected by Lillard and a colleague, cover the complete history of published

compulsory education laws for each state. This compilation of these data was facilitated by the presence at Cornell University of one of the most complete collections of state statutes in the United States. Figures 1 and 2 graphically illustrate the changes in the state compulsory education policies from 1930 to 2002 and show changes in policies in the average state during the time period our sample of women were affected by policies governing school entry and exit.

We use several sample restrictions for the study. We exclude observations if their mothers were living abroad when the compulsory schooling laws most likely took effect and those for whom data were missing. Each observation is at the child-year level. Sample sizes vary with the dependent variable we use. The sample size for whether the child had any illness that required medical attention or treatment in past 12 months was the largest with 43,154 child-year observations.

Table 1a and 1b show selected descriptive statistics for children and mothers for the whole sample and for samples of mothers who are high school dropouts and mothers who completed high school. Overall, mothers have an average of 12.3 years of education. High school dropout mothers are slightly younger, less likely to be married and more likely to be Hispanic or black.

In Figures 3 to 10 we present a first cut of the data. There we plot the bivariate relationship between children's health measures and mother's education across the whole education distribution. While the bivariate relationships show no clear trend for most outcomes, mothers who are high school dropouts were less likely to have reported that their child had an illness that required a doctor's care and they reported that their child was ill less than mothers who graduated from high school. As we will show below in the multi-variate analyses, these data likely reflect some of the complicated tradeoffs to which our simple model above points.

5. Results

5.1 OLS Results

The first row of Table 2 shows the results from OLS regressions. Each column represents a separate regression with a different child health measure as the dependent variable. The coefficient and robust standard error on the mother's education variable are shown.

The OLS results in Table 2 suggest that when the marginal woman completes high school instead of dropping out, she is more likely to report that her child had an illness that required medical attention or treatment in past 12 months, reports that her child had more such illnesses, and it is more likely that her child broke or dislocated a bone in the past year. The OLS results also suggest that women who complete high school will have children who are heavier and taller for their age than the average child of women who dropped out. To try to identify whether this relationship is causal, we turn to the instrumental variable regression results reported in the second row of Table 2.

5.2 IV Results

The second row in Table 2 shows results from our IV regressions.[7] The magnitude and even the sign of our IV estimates vary from our OLS estimates. Except for the results on weight of age and height for age, there is stronger evidence that children are more likely to be have seen a doctor for treatment (more times) and are more likely to have broken or dislocated a bone if their mothers completed high school. The F-statistics reported in the bottom row show that our policy variables jointly predict the probability a woman completes high school in all samples.

Mother's high school completion increases by 17.6 percentage points (51 percent) the probability that a mother reported her child was ill enough that she sought medical care in the

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[7] Appendix Table 1 presents results from one of our 1st stage regressions. All instruments except for permitted school exit age (where there is only cross-sectional variation) have expected signs.

past 12 months. The results suggest that children of mothers who complete high school are ill slightly more often (0.523 times more) than children whose mothers drop out. The results also suggest that mothers who complete high school have children who are substantially more likely to dislocate or fractured a bone over a 12 month period. Once one accounts for the endogeneity of high school completion, children of mothers who complete high school are no more or less likely to be heavier or taller for their age than are children of mothers who dropped out of high school.

As our simple model suggests above, the mix of time and medical inputs should vary with educational attainment but it is not immediately obvious how. We suggest that the data we have on health "outcomes" is actually a mixture of medical treatment that more educated mothers choose rather than spending time themselves treating the illnesses at home. Our analysis does not control for other behavioral differences of high school educated and high school dropout mothers that may cause their children to be at greater risk of getting sick and/or breaking a bone. For example, we do not control for whether a child participates in high risk sports (e.g. skiing, hockey) that may be more prevalent among children with better educated mothers. We also do not directly investigate how employment probabilities and wages (opportunity costs) differ for women who complete high school. Another possibility is that higher maternal education changes the opportunity cost of maternal time, increasing employment and decreasing direct time with children. The literature on the effect of maternal employment on child health shows some negative effects related to overweight (Anderson Butcher and Levine, 2002) and accidents (Currie and Hotz, 2001, for African American mothers), and universal Canadian daycare on a variety of child health outcomes (Baker, Gruber, and Milligan, 2005).

6. Robustness Checks

To test the validity of our instrumental approach, we report, in Table 3, results from models of behavior that we expect to be uncorrelated with a mother's educational attainment. The outcomes we explore as "anti-tests" include whether a child uses his left or right hand to write, throw a ball, or brush his teeth. Our instrumented education measure is uncorrelated with all of these outcomes.

In Table 4 we examine our conjecture that education may not only affect the mix of health inputs (time and purchased inputs) that a mother chooses but that education also affects other choices that affect a child's health. We run 2SLS models of a mother's age at child birth, whether she is covered by health insurance, whether her child was in child care from age 0 to age 2, and whether the mother is working (when the child outcome is measured). In each case we test whether those outcomes systematically differ for women who complete high school relative to women who drop out of high school. Not surprisingly, women who complete high school are more likely to be older when they first give birth, have health insurance, and have her son or daughter in child care at younger ages. The results suggest that women who graduate from high school are not more likely to be working than are women who dropped out.

In Table 5 we rerun the models of weight, BMI, and height for age using a subsample of the children whose height and weight were measured by interviewers (rather than self-reported). Both the OLS and 2SLS results are very similar to the earlier findings. The only difference is that now, mother's high school completion increases percentile for height-for-age by 9.494. The similarity of the results may imply that earlier results do not suffer from reporting bias.

Finally, in Table 6, we run a set of regressions that include as right-hand side variables the behaviors examined in Table 5 (child care use, health insurance status, and employment) plus a variable that indicated whether the child was ever in child care and a variable to flag those

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children who have a chronic condition that requires regular treatment. We interact each of these variables with the instrument education variable to see capture the correlation between education and these outcomes. While we recognize that these are largely outcomes of choice, we run the regressions as a tentative exploration of the more complex picture of how maternal education might be affecting child health.

The results show a generally consistent pattern. Children are more likely to be ill enough to see a doctor (more often) and are more likely to have broken a bone if they have a chronic condition, are in child care now or ever, live in a family that has health insurance, or have mothers who work. However, the association between these factors and the health outcome is lower for children whose mothers are high school graduates relative children whose mothers are high school dropouts. These patterns are preliminary evidence that much more digging needs to be done to understand how child health varies with maternal differences in education (on this margin).

7. Conclusions

We use an IV approach to examine the causal effect of mother's high school education on child health using the 1979-2002 waves of the NLSY79 and the 1990-2002 waves of the NLSY79CY. To instrument education, we use state compulsory education and high school graduation requirement policies. We find that mothers who complete high school are more likely to report their child was ill enough to need a doctor, that their child was ill more times, and that their child was more likely to have fractured or dislocated a bone in the past 12 months that required medical attention or treatment. Across samples of mothers who dropped out of high school and who completed high school, we find no difference in the date of their children's last routine health checkup, percentiles for weight-for-age, height-for-age, BMI-for-age, or in the

probability of children at risk of overweight and of being overweight. When we examined the possible mechanisms, we found that mother's high school education increases mother's age at child's birth, health insurance coverage and child care use. We also find suggestive evidence of a much more complex set of behaviors that are causally related to education (child care use, health insurance status, fertility decisions) and that likely affect child health. This preliminary evidence suggests that much more work needs to be done before one can strongly conclude that child health does or does not systematically vary with differences in maternal education on the margin we study (or on other educational margins).

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Figure 1:
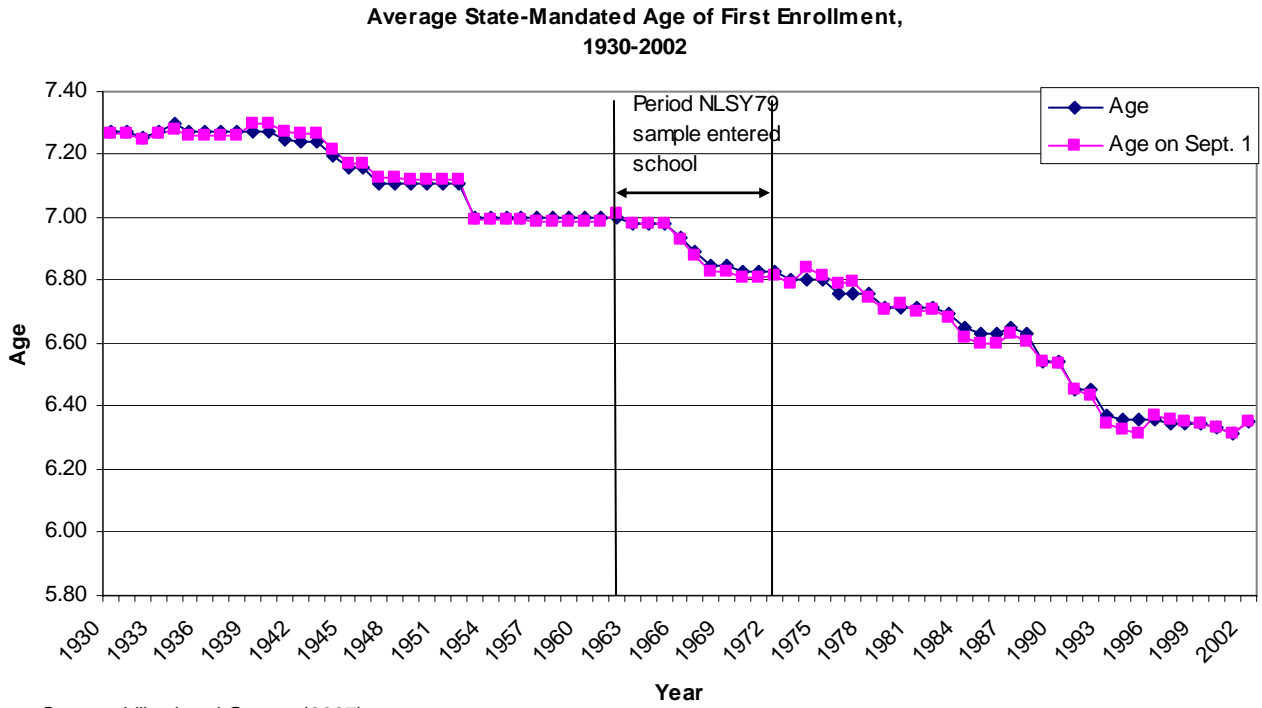
Average State-Mandated Age of First Enrollment, 1930-2002

Source: Lillard and Gerner (2007)

Figure 2:

Average State-Mandated Minimum Age of Permitted School Leaving, 1930-2002

Source: Lillard and Gerner (2007)

Figure 3:

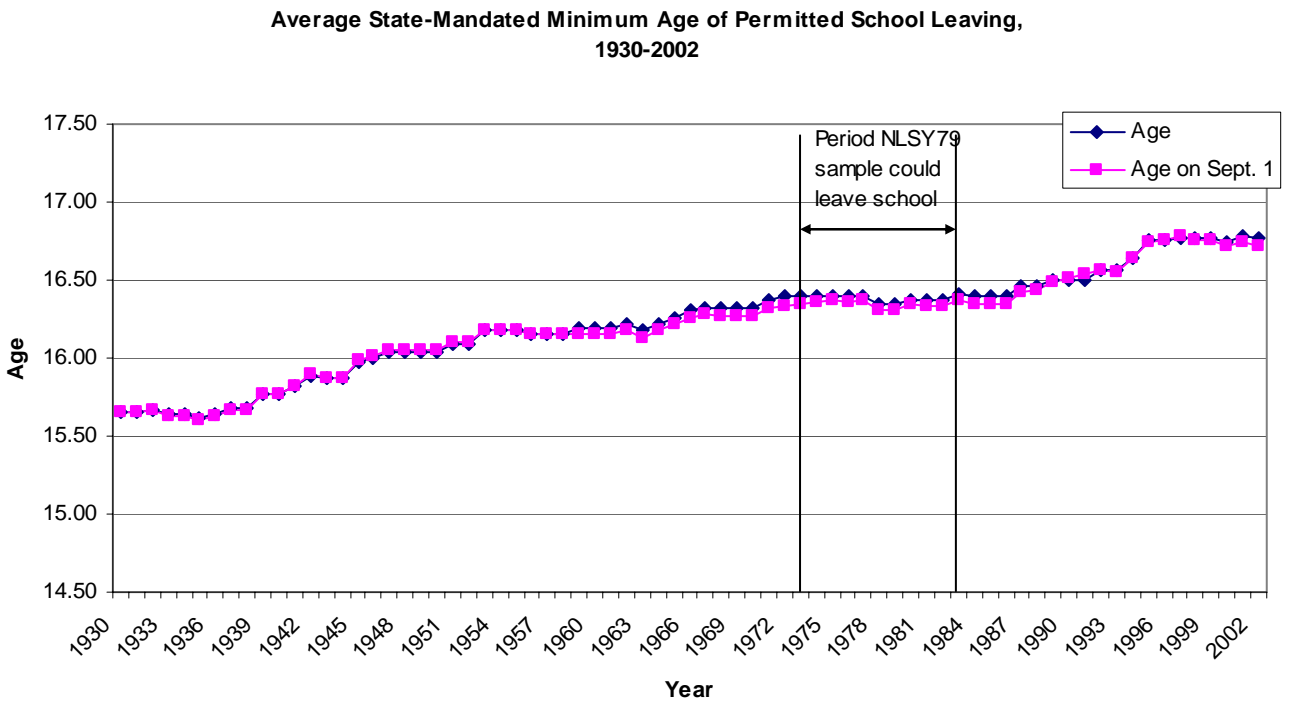**Average Percentages of Children with Different Times of Last Routine Checkup by Mother's Years of Education**
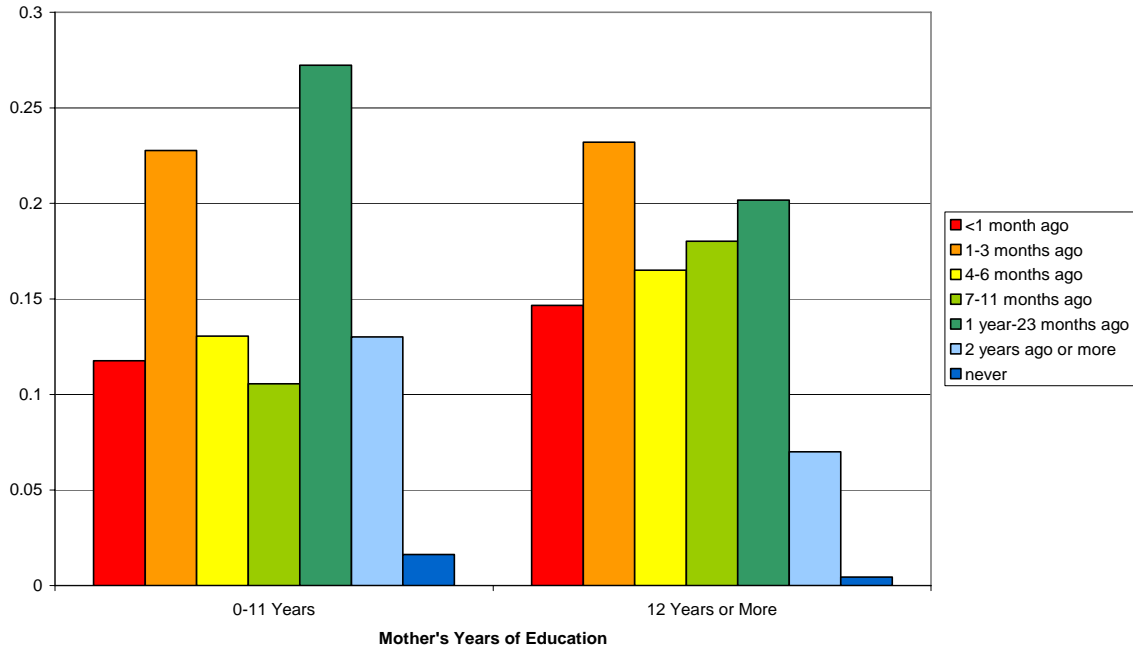

Figure 4:

Percentage of Children Ever Had Illness Past 12 Months by Mother's Years of Education
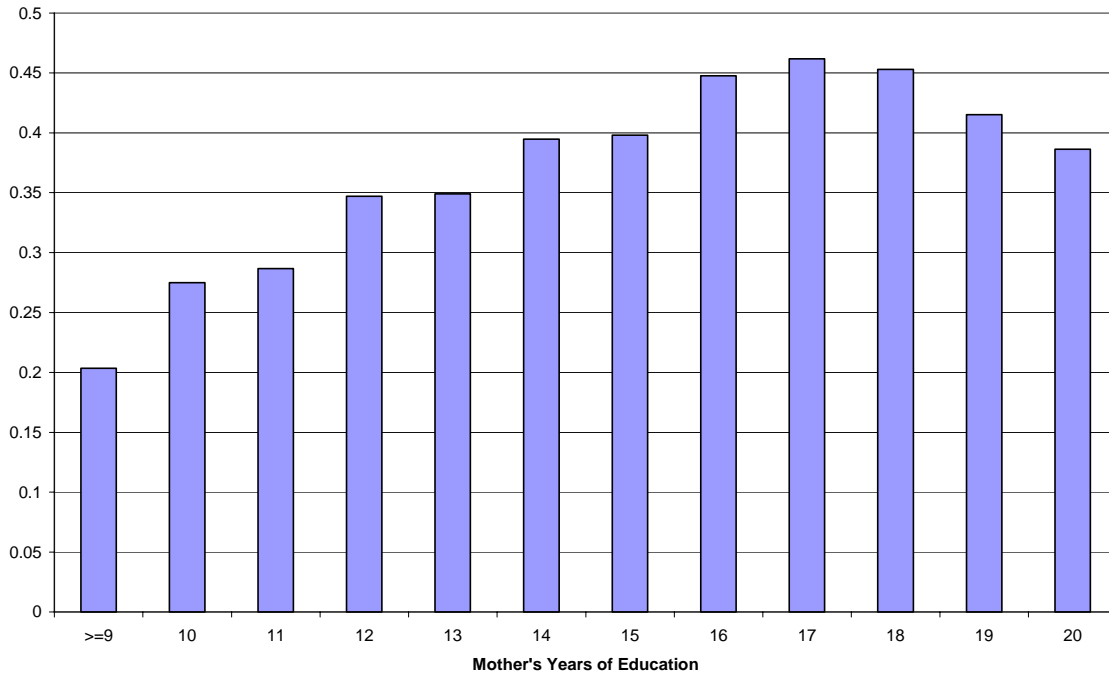
Figure 5:

Number of Illnesses Past 12 Months by Mother's Years of Education
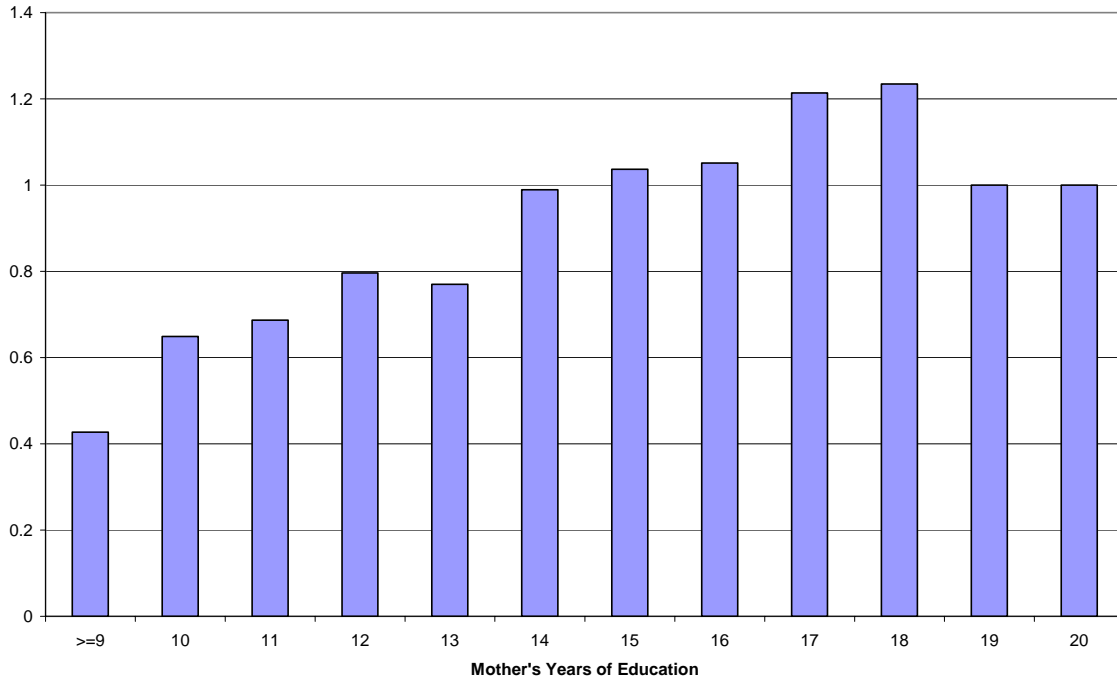
Figure 6: Average Percentiles for Weight-for-Age by Mother's Education

Average Percentile for Weight-for-Age by Mother's Years of Education
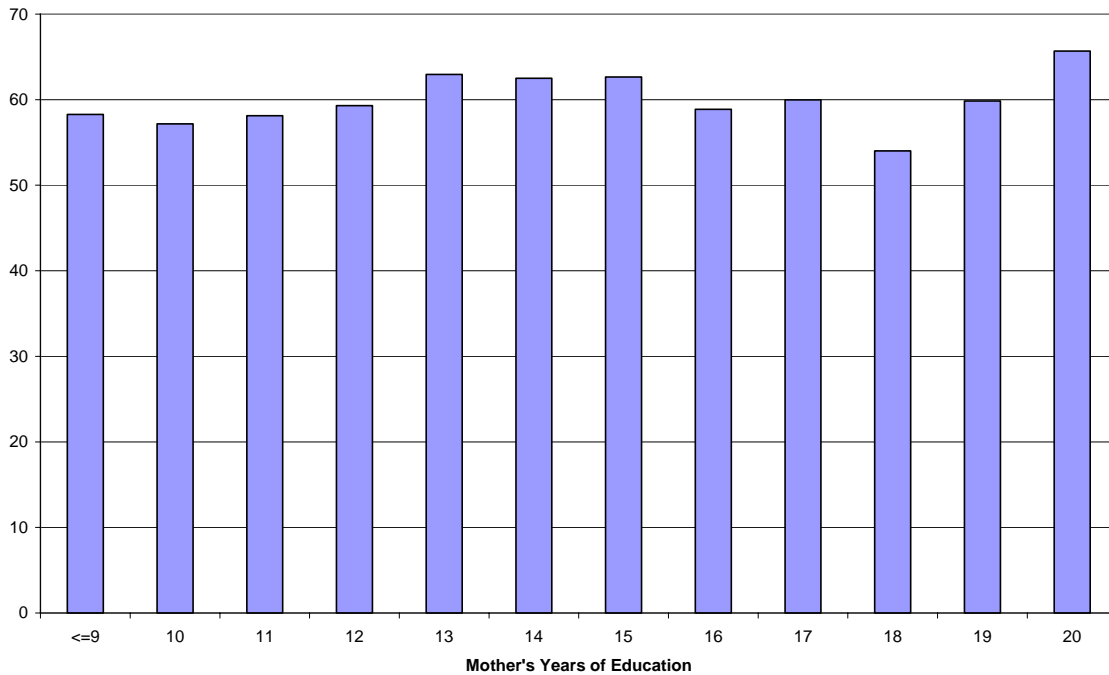
Figure 7:

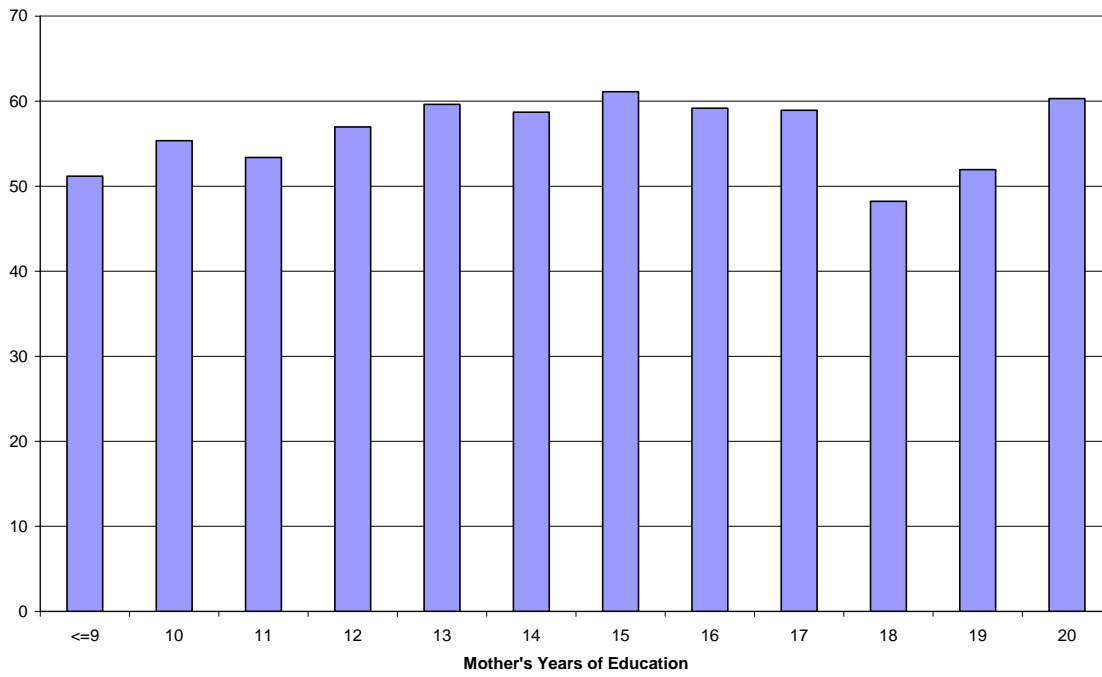**Average Percentile for Height-for-Age by Mother's Years of Education**

Figure 8:

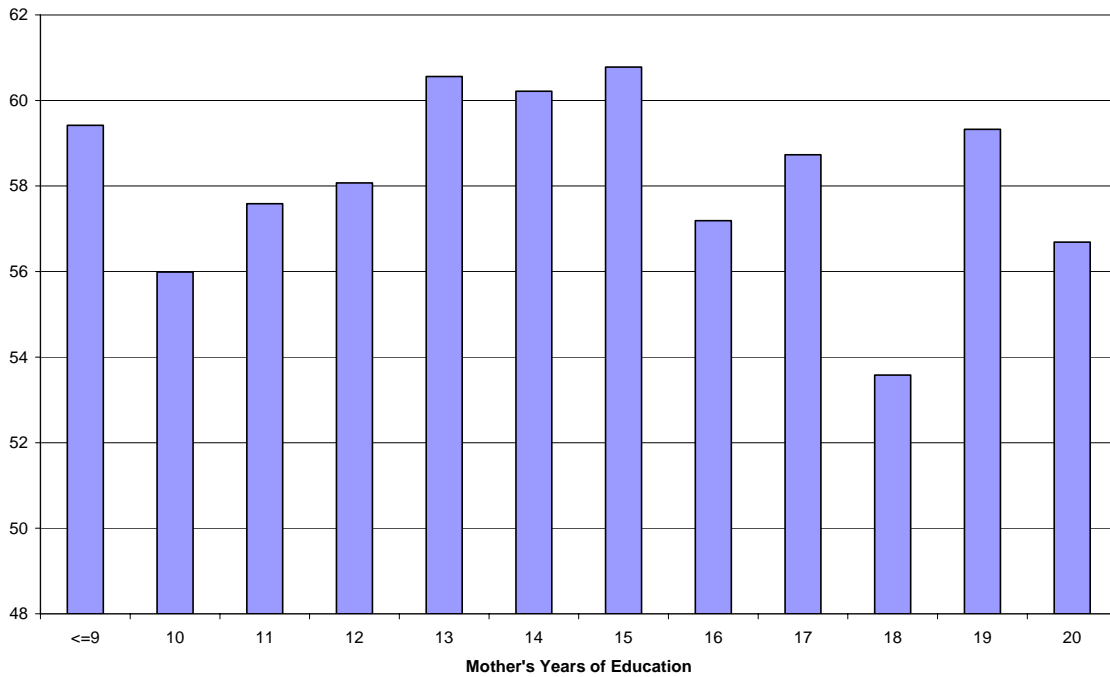**Average Percentile for BMI-for-Age by Mother's Years of Education**

Figure 9:

Percentage of Children At Risk of Overweight Mother's Years of Education
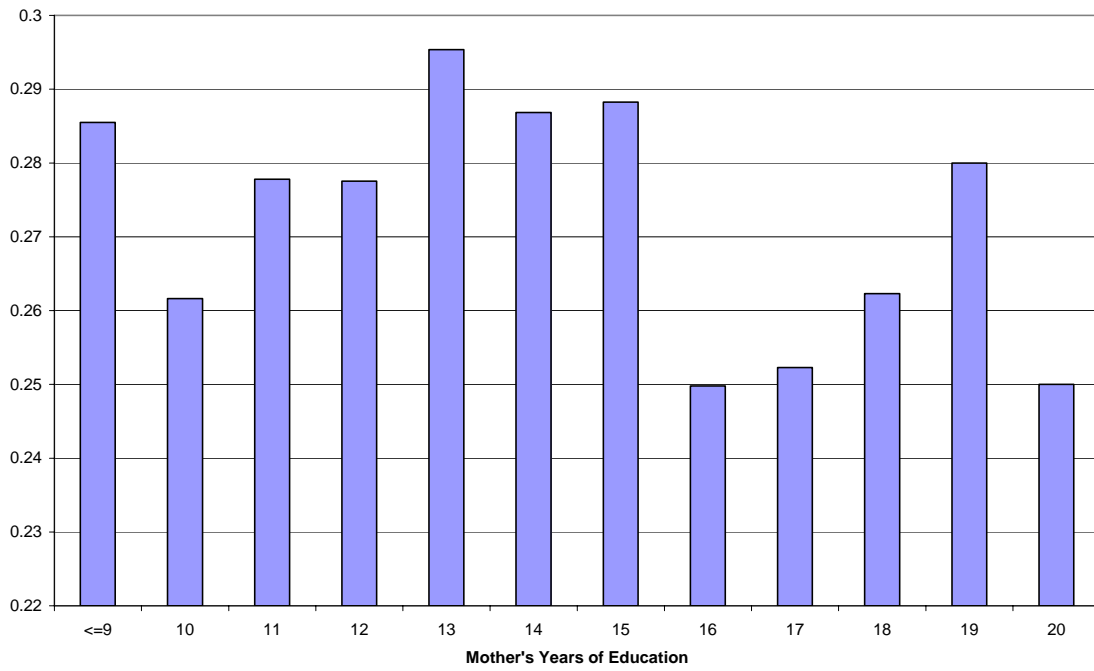
Figure 10:

Percentage of Overweight Children by Mother's Years of Education
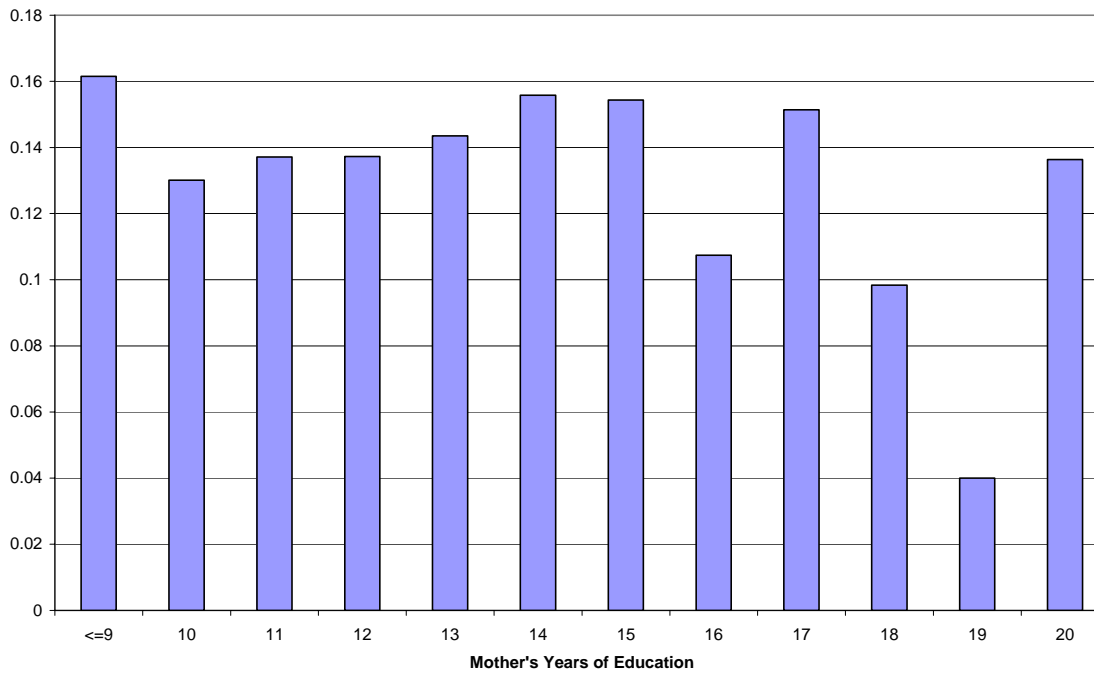
Table 1a: Child's and Mother's Characteristics: All Children and by Mother's Education (Dependent Variable: Ever Ill in Past Year)

Variable	All	HS dropout	HS or more
child's age	7.449 (4.345)	8.150 (4.454)	7.196 (4.278)
child's sex: female	0.492 (0.500)	0.494 (0.500)	0.491 (0.500)
child's race: Hispanic	0.202 (0.401)	0.303 (0.460)	0.165 (0.372)
child's race: black	0.305 (0.460)	0.348 (0.476)	0.289 (0.453)
child's race: non-black, non-hispanic	0.493 (0.500)	0.348 (0.477)	0.546 (0.498)
mother's education in years	12.349 (2.505)	9.464 (1.760)	13.389 (1.828)
mother's age	32.880 (4.914)	31.352 (4.804)	33.430 (4.836)
mother's marital status: never married	0.148 (0.355)	0.238 (0.426)	0.115 (0.320)
mother's marital status: married	0.644 (0.479)	0.481 (0.500)	0.703 (0.457)
mother's marital status: separated	0.079 (0.270)	0.131 (0.338)	0.060 (0.238)
mother's marital status: divorced	0.120 (0.325)	0.134 (0.341)	0.115 (0.319)
mother's marital status: widowed	0.009 (0.093)	0.015 (0.121)	0.007 (0.081)
N	43154	11430	31724

Note: An observation is a person-year at the child level.

Table 1b: Child Health Outcomes: All Children and by Mother's Education

Variable	All	HS dropout	HS or more
last check up: 1yr ago or more	0.326 (0.469)	0.356 (0.479)	0.315 (0.465)
N	42889	11330	31559
ever been ill past year	0.346 (0.476)	0.264 (0.441)	0.376 (0.484)
N	43154	11430	31724
# of times ill past year	0.821 (1.948)	0.627 (1.935)	0.890 (1.948)
N	43094	11409	31685
ever had bone fractures past year	0.025 (0.157)	0.020 (0.140)	0.027 (0.163)
N	35361	8795	26566
percentile: weight-for-age	56.682 (30.417)	54.684 (30.790)	57.681 (30.180)
N	21626	7203	14423
percentile: height-for-age	55.041 (31.598)	51.931 (31.589)	56.730 (31.476)
N	17893	6297	11596
percentile: BMI-for-age	55.883 (33.076)	54.839 (33.088)	56.449 (33.058)
% at risk of overweight	0.268 (0.443)	0.258 (0.438)	0.273 (0.446)
% overweight	0.137 (0.344)	0.134 (0.341)	0.139 (0.346)
N	17786	6256	11530

Table 2: OLS and 2SLS Regressions

	lastcheckup	ill past year		bone fracture past year
	>=1yr ago	ever	number	ever
OLS	-0.005	0.053***	0.089***	0.006***
	(0.009)	(0.006)	(0.028)	(0.002)
2SLS	0.009	0.180**	0.542***	0.035***
	(0.060)	(0.072)	(0.183)	(0.009)
N	42889	43154	43094	40851
F(k, N-k)	87, 42801	87, 43066	87, 43006	87, 43763
Fstat	142.06	142.81	142.57	135.00

	Percentiles				
	wt-for-age	ht-for-age	BMI-for-age	at risk of overwt	Overwt
OLS	1.928**	4.152***	0.179	-0.008	-0.016*
	(0.843)	(0.939)	(0.901)	(0.013)	(0.009)
2SLS	-2.537	8.122	-4.843	-0.091	-0.030
	(5.903)	(5.577)	(6.839)	(0.078)	(0.053)
N	27885	24140	23939	23939	23939
F(k, N-k)	87, 27797	87, 24052	87, 23851	87, 23851	87, 23851
Fstat	89.74	77.86	77.59	77.59	77.59

Note: *** Significant at 1% level, *** Significant at 5% level, * Significant at 10% level
Robust standard errors are in parenthesis. Each regression includes controls for child's sex, race, age, family size, number of siblings and mother's age and marital status, characteristics of the child's state of residence when the child health measure was taken (the ratio of employed men to women, the seasonally-adjusted unemployment rate, real median wages, the maximum value of the federal and state EITC for a single mother with two children, the income eligibility limit for Medicaid eligibility for pregnant women, the annual employment growth rate, and the amount of federal housing money spent per 1,000 residents in the state), a vector of characteristics of the mother's state of residence when she was affected by compulsory school leaving laws (personal income, per capita personal income, average earning from industries, construction, manufacturing and service) and a vector of characteristics of the child's county of residence when the child health measures were taken (total active non-federal MDs, total patient care by non-fed MDs, total number of hospitals, and total number of hospital admissions and total number of hospital beds). Standard errors are clustered at the state level (i.e. mother's state of residence when she was affected by school exit laws). All regressions include fixed effects for mother's state of residence when she is affected by school entry policies. Instruments used in 2SLS regressions are: the minimum age of compulsory entry, the minimum age of permitted school leaving, the difference in the cutoff month for school entry and child's birth month (i.e. cutoff month minus birth month), interaction of this difference with the minimum age of compulsory entry, the difference in the child's birth month from June (i.e. counting back from June), interaction of this difference with the minimum age of permitted school leaving, total number of courses required for high school graduation, an indicator variable for states that do not set a statewide minimum number of courses for high school graduation, first factor calculated from factor analysis using the number of academic courses required for high school graduation, first factor obtained from factor analysis using the number of elective courses required for high school graduation, an indicator variable for states that do not set a statewide minimum number of courses for high school graduation, an indicator variable for mothers whose compulsory school entry policies were assigned assuming that she lived in the same state as her first reported state of residence, and an indicator variable

for mothers whose compulsory school entry policies were assigned assuming that she lived in the same state as her first reported state of residence.

Table 3: Anti-Test: Second Stage Regression

	right/left handedness		
	writing	throwing	brushing
2SLS	-0.089 (0.057)	0.194 (0.169)	0.272 (0.176)
N	14354	14344	14330
F(k, N-k)	85, 14268	85, 14258	85, 14244
Fstat	34.74	34.66	34.61

Note: *** Significant at 1% level, *** Significant at 5% level, * Significant at 10% level
Control variables included in these models are the same as those described in the note to Table 2.

Table 4: Mechanisms

	mother's age at child birth	health insurance	child care	Mother working
OLS	0.028* (0.016)	0.072*** (0.009)	0.133*** (0.012)	0.147*** (0.010)
2SLS	0.825** (0.356)	0.452*** (0.064)	0.315*** (0.090)	0.096 (0.154)
N	57829	43281	4750	57829
F(k, N-k)	87, 57741	87, 43193	85, 4664	87, 57741
Fstat	195.40	143.30	19.38	195.40

Note: *** Significant at 1% level, *** Significant at 5% level, * Significant at 10% level
Control variables included in these models are the same as those described in the note to Table 2.

Table 5: OLS and 2SLS Regressions Only for Children with Measured Values

	percentiles				
	wt-for-age	ht-for-age	BMI-for-age	at risk of overwt	overwt
OLS	2.735*** (0.932)	4.999*** (0.997)	0.775 (0.993)	-0.0008 (0.014)	-0.009 (0.009)
2SLS	-0.337 (5.429)	9.494* (5.399)	-4.501 (5.763)	-0.091 (0.075)	-0.027 (0.051)
N	22991	21850	20492	20492	20492
F(k, N-k)	85, 22905	85, 21764	85, 20406	85, 20406	85, 20406
Fstat	62.17	59.98	56.29	56.29	56.29

Note: *** Significant at 1% level, *** Significant at 5% level, * Significant at 10% level
Control variables included in these models are the same as those described in the note to Table 2.

Table 6: 2SLS Regressions with intervening behaviors and interactions

	lastcheckup	ill past year		bone fracture past year
	>=1yr ago	ever	number	Ever
Hs	0.237	0.458***	1.356***	0.108***
	(0.215)	(0.168)	(0.495)	(0.035)
require treatment	-0.199***	0.367***	1.891***	0.031***
	(0.032)	(0.025)	(0.270)	(0.008)
require treatment*hs	0.018	-0.076***	-0.204	-0.023**
	(0.038)	(0.027)	(0.304)	(0.011)
childcare now	-0.160***	0.054	1.417*	-0.009
	(0.030)	(0.059)	(0.760)	(0.005)
childcare now*hs	0.050	0.032	-0.834	0.009
	(0.030)	(0.065)	(0.765)	(0.007)
childcare ever	0.033	0.075***	0.154**	0.011
	(0.029)	(0.019)	(0.073)	(0.007)
childcare ever*hs	-0.049	-0.066***	-0.157*	-0.013*
	(0.033)	(0.020)	(0.078)	(0.007)
insurance	0.006	0.224***	0.712***	0.052***
	(0.101)	(0.080)	(0.220)	(0.018)
Insurance*hs	-0.172	-0.283**	-0.874**	-0.079***
	(0.166)	(0.126)	(0.376)	(0.026)
work	0.079	0.082**	0.240**	0.017*
	(0.050)	(0.039)	(0.174)	(0.009)
work*hs	-0.080	-0.154**	-0.512**	-0.027**
	(0.074)	(0.062)	(0.175)	(0.012)
N	36241	36179	36132	29925
F(k, N-k)	96, 36144	96, 36082	96, 36035	96, 29828
Fstat	2987.72	2909.17	2902.26	2499.52

Note: *** Significant at 1% level, *** Significant at 5% level, * Significant at 10% level
Control variables included in these models are the same as those described in the note to Table 2.

Appendix Table 1: 1st Stage Results from 2SLS Regression using Sample from Regression using Ever Ill in Past Year as Dependent Variable

	HS or more
Compulsory school entry age	0.005 (0.009)
Permitted school exit age	-0.040*** (0.005)
Cutoff month-birth month	0.012* (0.006)
Interaction: entry age*(cutoff month-birth month)	-0.002* (0.001)
Difference between June & birth month	-0.024*** (0.007)
Interaction: entry age*(June-birth month)	0.004*** (0.001)
Total # of courses for HS graduation	-0.001 (0.004)
1st factor from academic courses for HS graduation	-0.002 (0.009)
1st factor from elective courses for HS graduation	0.005 (0.012)
No statewide requirement for HS graduation	0.007 (0.009)
Assumed mother lived in the same state as her 1st reported state of residence for school entry policy	-0.075*** (0.009)
Assumed mother lived in the same state as her 1st reported state of residence for school exit policy	-0.258*** (0.015)
N	43154
F(k, N-k)	86, 43067
Fstat	119.65

Appendix A1: Algorithms Used to Merge in the Instruments

To estimate the IV model, instruments (compulsory education policies on school entry and school leaving and high school graduation policies) were merged with the mother's record by mother's state of residence in the relevant years. The instruments were used in the first stage regression on mother's own education. Below, we explain how we merged mother's data with each type of instruments.

1. Compulsory Education Policies: School Entry
We assign the minimum age of compulsory entry, to each mother using her state of birth and the year she was required to enter school in her state of birth. Consider mother A who was born in state X in 1960. She became age 4 in 1964, age 5 in 1965, age 6 in 1966, age 7 in 1967, age 8 in 1968, age 9 in 1969, and age 10 in 1970. The minimum age of compulsory entry in state X in 1964 was 5, in 1965 was 6, in 1966 was 6, in 1967 was 6, in 1968 was 6, in 1969 was 6, and in 1970 was 6. Therefore she was required to enter school in 1966. If the same mother A were born in state Y, she will be required to enter school in 1967.

2. Compulsory Education Policies: School Leaving
We assign the minimum age of permitted school leaving to each mother using her state of birth and the year she became eligible to drop out from school in her state of birth. Again consider mother A who was born in state X in 1960. She became age 12 in 1972, age 13 in 1973, age 14 in 1974, age 15 in 1975, age 16 in 1976, age 17 in 1977, and age 18 in 1978. The minimum age of permitted school leaving in state X in 1972 was 14, in 1973 was 14, in 1974 was 15, in 1975 was 15, in 1976 was 15, in 1977 was 15, and in 1978 was 15. Therefore she became eligible to drop out from school in 1975. If the same mother A were born in state Y, she will be eligible to drop out from school in 1974. Note that although state Y increased the minimum age of permitted school leaving to age 16 in 1975 when she is still age 15, she does not need to go back to school since she has already reached age 14 when age 14 was the minimum age of permitted school leaving in state Y.

year	age	State X		State Y	
		min age of comp entry	max age of perm leaving	min age of comp entry	max age of perm leaving
1960	0	5	14	7	14
1961	1	5	14	7	14
1962	2	5	14	7	14
1963	3	5	14	7	14
1964	4	5	14	7	14
1965	5	6	14	7	14
1966	6	**6**	14	7	14
1967	7	6	14	**7**	14
1968	8	6	14	8	14
1969	9	6	14	8	14
1970	10	6	14	8	14
1971	11	6	14	8	14
1972	12	6	14	8	14
1973	13	6	14	8	14
1974	14	6	15	8	**14**
1975	15	6	**15**	8	16
1976	16	6	15	8	16
1977	17	6	15	8	16
1978	18	6	15	8	16

3. High School Graduation Requirement Policies

Four graduation requirement policy variables were used as instruments: total number of courses required for high school graduation, an indicator variable for states that do not set a statewide minimum number of courses for high school graduation (they instead let school districts set the minimum), first factor calculated from factor analysis using the number of academic courses required for high school graduation, and first factor obtained from factor analysis using the number of elective courses required for high school graduation. We assign these instruments to each mother using her state of birth and the year she was age 15.