Is Biology Destiny? Birth Weight and Life Chances

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Two key questions are addressed regarding the intersection of socioeconomic status, biology, and low birth weight over the life course. First, do the income and other socioeconomic conditions of a mother during her pregnancy affect her chances of having a low-birth-weight infant net of her own birth weight, that of the father, and other family-related, unobserved factors? Second, does an individual's birth weight status affect his or her adult life chances net of socioeconomic status? These questions have implications for the way we conceive of the relationship between socioeconomic status and health over the life course, specifically in sorting out causal directionality. We use intergenerational data from the Panel Study of Income Dynamics, for the years 1968 through 1992. Results of sibling comparisons (family-fixed-effects models) demonstrate that maternal income does not appear to have a significant impact on birth weight. However, low birth weight results in lower educational attainment net of other factors. These findings suggest that, when considered across generations, causality may not be as straightforward as implied by cross-sectional or unigenerational longitudinal studies.

The relationship between socioeconomic status and health has long intrigued social scientists. However, since its inception this research tradition has been plagued by questions of causal directionality. Namely, individuals may be sick because they are poor; alternatively, it may be their ill health itself that plunges them into poverty (e.g., through job loss due to sickness). It is also possible that the relationship between health and socioeconomic status over the life course is spurious, reflecting other underlying dynamics such as genetic disposition (Evans, Barer, and Marmor 1994; Link, Northridge, and Phelan 1998).

As a measure literally at the starting gate of life, birth weight is a particularly appealing heuristic tool for examining the relationship between morbidity and socioeconomic status. We know that a baby is not responsible for its own condition at birth; likewise, we know that an infant's future education, occupation, or income does not affect its birth weight. In fact, during the late 1970s, the British government commissioned a report on social inequalities in health. A major conclusion of the report was that "biological programming" of adult health status occurs to a great extent during the fetal and infant states of development (Vagero and Illsley 1995:220). Social scientists have since paid increasing attention to the consequences of poverty and social inequality early in the life course (Aber et al. 1996) particularly to the issue of low birth weight (defined as less than 2,500 grams or 5 pounds 8 ounces) and preterm delivery (of which birth weight is

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often a good proxy indicator). Low birth weight is a particularly important health measure because research shows that the infant mortality rate (a common indicator of social development) is highly sensitive to birth weight (Luke et al. 1993).[1]

This increasing focus on socioeconomic and health conditions early in life appears to obviate the problem of reverse causality. However, when both health and socioeconomic status are viewed in a multigenerational framework, we find that even in examinations of perinatal health issues there may be some degree of reverse causation. It could be that those parents who are low income (or unmarried, for instance) also tend to suffer from ill health (as has been shown by a number of classic studies) and are passing these characteristics on to their offspring through behavioral mechanisms. There may even be a genetic predisposition to low birth weight that tends to be found more frequently in low-income populations (and that partially accounts for their poverty). To untangle these intertwined possibilities, we attempt to understand the intergenerational nature of low birth weight with respect to its association with income and its cofactors. First, we ask: Do maternal age and income during pregnancy affect the birth weight of the child net of the mother's own birth weight status (and that of the baby's father)? Second, what are the long-term, lingering effects of low birth weight on the life chances of an individual—as measured by educational attainment?

There are several ways in which the social and biological worlds might interact with respect to birth weight, and what follows is by no means an exhaustive list of the possible combinations of effects and noneffects: (1) Low income (and its cofactors) depresses birth weight but low birth weight itself has no effect on adult outcomes. This would suggest that studies which have found negative effects of low birth weight on social indicators have not adequately considered the social disadvantages for which birth weight may be a proxy, resulting in a spurious association. (2) Maternal age and income have no effect on birth weight, but birth weight has a causal impact on adult poverty, thereby giving the spurious impression that poverty has an effect on birth weight when the causation is really the reverse. (3) Income and other demographic factors have an effect on birth weight with the added feature that low birth weight itself predicts a baby's risk of being disadvantaged as an adult. This dynamic implies a sociobiological vicious circle in which health conditions have an important mediating role in determining socioeconomic position and likewise, socioeconomic status has an impact on the health status of the next generation (see Figure 1).

RESEARCH STRATEGY

To examine the intergenerational relationship among income, life chances, and birth weight, we use long-term longitudinal data from the Panel Study of Income Dynamics (PSID). A description of the PSID study design can be found in Hill (1992) or Duncan and Hill (1989). The data set includes information on the socioeconomic histories of families as well as on the outcomes of multiple children from the same families who were in the original sample, moved into it, or were born to sample members. Our overall research strategy is that we first present the effects of our variables in a series of nested logistic regression models. Then we employ fixed-effects models to eliminate potentially biasing unobservable factors. Family-fixed-effects models represent an effective way of factoring out unobserved differences between respondents that may be generating biased effects in traditional regression models.[2] (For a fuller discussion of the

[1] Low-birth-weight infants are also said to suffer developmentally, although much of this research is plagued by the problem of unobserved variable bias (for a review, see Aber et al. 1996; McGaughey et al. 1991; Rich-Edwards et al. 1997; Sorensen et al. 1997). Further complicating the issue is the fact that poverty and other socioeconomic circumstances may play a role in determining the consequences of low birth weight (Bradley et al. 1994).

[2] In fact, much of the literature on the effects of poverty (on a range of outcomes) is plagued by this problem of unobserved heterogeneity. Korenman and Miller (1997) and Duncan et al. (1998) have tackled this issue of unobserved variable bias using similar fixed-effects approaches and have arrived at mixed results.

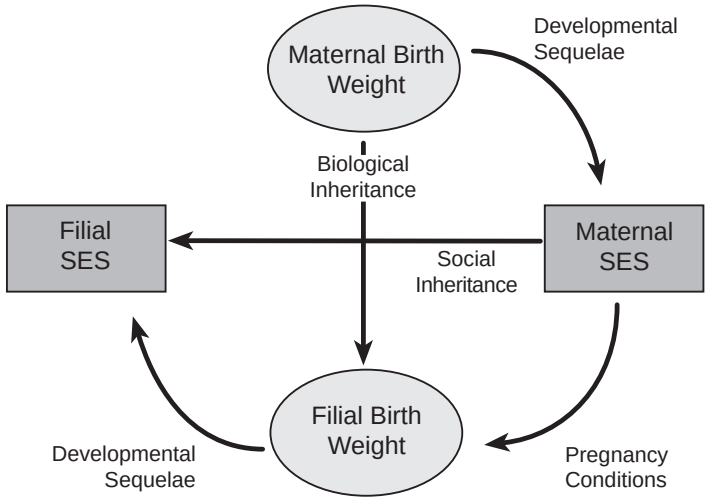

Figure 1. Bidirectional Relationship between Infant Health and Socioeconomic Status

merits and drawbacks of this methodology, see Griliches 1979.)

Using this approach, we develop conditional logistic regression models to assess the impact of maternal poverty and other cofactors on the risk of filial low birth weight. We then use the same methods to model the impact of the respondent's birth-weight status on his or her chances of graduating from high school in a timely fashion (by the nineteenth birthday). Although this second outcome is temporally distal from the predictors of interest—birth weight and the conditions during pregnancy—it is important to note that the sibling comparisons factor out all of the intervening differences to the extent that they are shared within the family. Our fixed-effects models compare brothers or sisters using their mother's identity as the grouping category.[3] Using this approach, the first part of the analysis addresses the effects of maternal poverty and its cofactors on low birth weight. To investigate this relationship, we use a subsample of the PSID that includes children born between 1968 and 1992 for whom birth weight information is available and whose mothers were in the sample during their pregnancy. The proportion of African American children in the sample is high because low-income households were oversampled in the PSID. The second sample—used for analysis of the effect of low birth weight on high school graduation—includes only those individuals who had reached their nineteenth birthday by the end of 1992 and who have a valid indicator of birth weight status. Both samples include only singleton births.[4]

Variables

Birth weight. In all analyses, we use a dummy variable for low-birth-weight status. In the models predicting birth weight, parental birth weight is included because it is a potentially biasing factor with respect to poverty. In the sibling comparisons, however, it drops out, and we do not control for parental birth weight when predicting educational attainment. (In fixed-effects-mod-

[3] This method is *not* the equivalent of what researchers such as Geronimus and Korenman (1993a, 1993b), Geronimus, Korenman, and Hillemeier (1994), and Hoffman, Foster, and Furstenberg (1993) call "sister comparisons." In their method, the sisters under comparison are the mothers of the children in this study, making these children cousins. Our method is equivalent to what Currie and Thomas (1995) and Rosenzweig and Wolpin (1994, 1995) do in some of their analyses.

[4] Tables of sensitivity analyses for the exclusion of singletons and those with missing data are available upon request. In the main model for low birth weight, we include dummy variables for missing information on parental birth weight, the most potentially biasing factor.

els, this is de facto controlled.) We did not anticipate an important, direct causal link between parental birth weight and filial educational attainment net of other characteristics, such as parental income, parental education level and filial birth weight.

SEX. The respondent's sex is included because research shows that the entire birthweight distribution of females is shifted to the left of that of males and thus females have a greater risk of being born at low birth weight than males. This variable is also included in the education analysis because females attain higher levels of education than do their male counterparts (U.S. Department of Education 1997).

BIRTH ORDER. A dummy variable indicates whether the individual was a first child (to his or her mother). Prior research has shown that first-borns may be at higher risk of low birth weight (Miller 1994). For the prediction of educational attainment, this term was also included because some researchers claim that first-borns enjoy educational advantages, although others have questioned this claim.

RACE. Research has documented that African Americans are about twice as likely as whites to be born at low birth weights, even after controlling for traditional measures of socioeconomic status (Collins 1997; Cramer 1995; Frisbie, Biegler, and de Turk 1997; Hummer 1993; Wilcox and Russell 1990). In our analysis we include a dummy variable indicating a black respondent.[5] We also include controls for race in the analysis of high school graduation. Note that race is de facto controlled in the fixed-effects models.

MOTHER'S AGE. In both sets of analyses, we control for young maternal age (< 18 years old). The literature shows that children born to mothers who are under age 18 or over age 34 are more likely to be of low birth weight. Some researchers have found that when family background is controlled using fixed-effects models like those employed in the current study that young maternal age has a positive impact on birth weight (Rosenzweig and Wolpin 1995). In addition, children born to young mothers may demonstrate lower levels of educational attainment than those born to older women, although some researchers argue that this may be the result of unobserved heterogeneity (Geronimus et al. 1994; McLanahan and Sandefur 1994).

INCOME-TO-NEEDS RATIO. This is a continuous variable constructed by dividing the total family income for a given year by the poverty threshold for the family size and type as determined by federal government. The time period for the birth weight analyses is the year prior to birth and thus includes the mother's pregnancy and/or the period immediately preceding it. In the education models, we use income in the first five years of life.[6] Researchers (e.g., Mayer 1997) have demonstrated that a five-year income measure captures a good degree of family economic variability and that the added predictive value of including additional years beyond five is not significant. Furthermore, Duncan et al. (1998) have shown that this period has the greatest impact on the completion of high school.

MATERNAL EDUCATION. We operationalize this variable as the highest grade completed by the mother by 1984. Thus, we do not model the effects of changes in maternal educational status between pregnancies but rather leave its entire effect to the common family component in the fixed-effects framework. It is worth noting, however, that Rosenzweig and Wolpin (1994) found that interpregnancy increases in maternal schooling have a positive impact on children's achievement test scores.

HIGH SCHOOL GRADUATION. For the analysis of the effects of low birth weight on educational attainment, the dependent variable is having completed high school by the end of the nineteenth year of life—that is, "on time." This outcome measure eliminates the issue of age differences among the sib-

[5] Latinos are a small proportion of the original PSID sample. We tested a dummy variable indicating "Spanish origin" but it was not significant and was dropped from the final models.

[6] The first year for which income information was available was 1967. Therefore, for those respondents born between 1965 and 1967, we use an average of the number of years that individual was in the sample between ages 0 and 5. For instance, someone born in 1966, would have a four-year income measure, 1967 to 1970, ages 1 to 4.

lings, which may yield differences in the level of educational attainment when measured by highest grade completed. Graduation on time is also a substantively important variable with respect to the life chances of young adults. Those who graduate "late" are more likely to have received a high school equivalency diploma (GED) than those who finished their secondary schooling "on time" (Cameron and Heckman 1993:5). An equivalency diploma, in turn, results in poorer economic outcomes when contrasted to actual high school graduation (Cameron and Heckman 1993). Finally, students who do not complete high school on time and thus are older when (and if) they continue their educational careers are less likely to attend four-year academic colleges than are "traditional" students (Horn and Carroll 1996).

FINDINGS

Our first objective is to determine—using a logistic regression approach—the impact of maternal age and poverty level on the birth weight of the infant. Model 1, Table 1 estimates the influence of these two factors during a mother's pregnancy on her child's birth weight.

In this basic model, we find that young maternal age and income—in the form of the income-to-needs ratio of the family in the year prior to the birth of the child—relate significantly to that child's birth weight. A one-unit increase in the maternal income-to-needs ratio about the mean is associated with a 13-percent decrease in the probability of being born of low birth weight. Young maternal age corresponds to a 34-percent increase in the probability of having a low-birth-weight infant relative to mature maternal age. Model 2 indicates that a negative relationship between the income-to-needs ratio and low birth weight persists in the presence of some important control variables—the mother's educational attainment and the child's sex, birth order, and race—although the impact of the income-to-needs ratio diminishes. A one-unit increase in the income-to-needs ratio is now associated with a 6-percent decrease in the probability of having a low-birth-weight child. In contrast, however, income and young maternal age lose their significance in Model 3 when parental birth weight status is included in the model (along with missing data indicators). The birth weights of both parents have a significant positive influence on the birth weight of the child. The probability of having a low-birth-weight child increases nearly four-fold if the mother was a low-birth-weight baby herself. (The corresponding figure is six-fold for children of low-birth-weight versus non-low-birth-weight fathers.) With the inclusion of the parents' birth-weight status, we find that the impact of income is largely spurious. Poor parents were themselves disproportionately born of low birth weight. The effect of income, net of parental birth-weight status, then, is negligible.

Last, we employ a fixed-effects model in order to factor out the effects of family-level unobservable variables that exist in common among children. Here, too, we find that income during pregnancy has no bearing on the birth-weight status of the child.[7]

The second portion of the intergenerational analysis explores the impact of birth-weight status on life chances as measured by educational attainment. To address this issue, we examine the chances of completing high school by the end of the nineteenth year of life; we use a logistic regression framework, and then a fixed-effects framework. The results, presented in Table 2, indicate that low birth weight negatively affects educational progress, even after factoring out family-specific conditions.

In a bivariate model, Model 1, in which we regress timely high school graduation on the child's birth-weight status, we find that having been born at a low birth weight significantly diminishes the likelihood of graduating from high school by one's nineteenth birthday. The probability of timely gradua-

[7] Dummy variables for poverty status and extreme poverty (< 50 percent of the poverty line) were tried but proved nonsignificant. The same is also true for income, logged income, income-squared and income-to-needs ratio squared. Interaction effects between parity and maternal age were also not significant. Neither was an indicator variable for maternal marital status at time of birth. The same patterns for nonsignificant terms also apply to the analysis presented in Table 2 as well.

Table 1. Coefficients from the Regression of Low Birth Weight on Maternal Socioeconomic Conditions: Logistic and Fixed-Effects Conditional Logistic Models

Variables	Statistics for Models 1–3		Logistic Regression Models			Fixed-Effects Model	Statistics for Fixed-Effects Model	
	Mean	S.D.	Model 1	Model 2	Model 3		Mean	S.D.
Socioeconomic Condition During Pregnancy								
Income-to-needs ratio	2.53	2.07	–.149*** (.027)	–.068* (.029)	–.038 (.032)	–.034 (.062)	1.98	1.81
Maternal age < 18 years	.12	.33	.333** (.113)	.212 (.119)	.113 (.132)	.019 (.235)	.16	.36
Control Variables								
Female child	.49	.50	—	.294*** (.084)	.356*** (.099)	.281* (.141)	.53	.50
First-born child	.39	.49	—	.122 (.088)	.160 (.099)	.174 (.137)	.30	.46
African American	.42	.49	—	.689*** (.093)	.400*** (.105)	—	—	
Maternal education	12.22	2.30	—	–.009 (.020)	.013 (.022)	—	—	
Parental Infant Health History								
Mother low birth weight [a]	.08	.27	—	—	2.010*** (.107)	—	—	
Father low birth weight [a]	.06	.24	—	—	2.875*** (.140)	—	—	
Missing data for mother low birth weight	.01	.08	—	—	.652 (.337)	—	—	
Missing data for father low birth weight	.22	.42	—	—	.843*** (.114)	—	—	
Constant	—		–1.864*** (.108)	–2.179*** (.261)	–2.988*** (.456)	—	—	
L^2	—		52.23	122.06	971.33	6.34	—	
Degrees of freedom	—		2	6	10	4	—	
Number of cases	8,213		8,213	8,213	8,213	987	987	
Number of clusters	—		4,197	4,197	4,197	312	—	

Note: Standard errors are in parentheses. Standard errors for Models 1 through 3 are robust to clustering by mother's identity.

[a] Fifty-three cases were missing data on mother's birth weight; 1,839 cases were missing data on father's birth weight.

*$p < .05$ **$p < .01$ ***$p < .001$ (two-tailed tests)

tion appears to be cut by more than one-third (38 percent). When that model is supplemented by including an income variable (Model 2), we find that the income-to-needs ratio of the family during the child's first five years of life also relates significantly to the probability of timely high school graduation. The probability is increased by 9 percent with a one-unit increase in the income-to-needs ratio about the mean. With the inclusion of a set of control variables (Model 3), we find that both the birth weight of the child and the family's income-to-needs ratio still have a strong impact on that child's likelihood of graduating from high school in a timely fashion. In this full model, the prob-

Table 2. Coefficients from the Regression of Timely High School Graduation on Low Birth Weight, Maternal Socioeconomic Circumstances, and Other Independent Variables: Logistic and Fixed-Effects Conditional Logistic Models

Variables	Statistics for Models 1–3		Logistic Regression Models			Fixed-Effects Model	Statistics for Fixed-Effects Model	
	Mean	S.D.	Model 1	Model 2	Model 3		Mean	S.D.
Perinatal Conditions								
Low birth weight	.07	.26	–.626* (.247)	–.598* (.248)	–.577* (.250)	–2.024** (.764)	.07	.25
Income-to-needs ratio, ages 0–5	2.36	1.59	—	.114** (.039)	.088* (.044)	.050 (.181)	2.49	1.34
Maternal age < 18 years	.04	.19	—	–.384 (.333)	–.424 (.345)	–.904 (.696)	.03	.18
Controls								
Female child	.47	.50	—	—	.439*** (.119)	.363 (.204)	.48	.50
First-born child	.42	.49	—	—	.199 (.124)	.112 (.198)	.28	.45
African American	.316	.47	—	—	–.111 (.140)	—	—	
Maternal education	12.06	2.22	—	—	.019 (.030)	—	—	
Constant	—		–.841*** (.239)	–1.456*** (.401)	–1.378** (.507)	—	—	
L^2	—		6.85	18.33	35.66	16.83	—	
Degrees of freedom	—		1	3	7	5	—	
Number of cases	1,183		1,183	1,183	1,183	476	476	
Number of clusters	—		675	675	675	183	—	

Note: Standard errors are in parentheses. Standard errors for Models 1 through 3 are robust to clustering by mother's identity.

*$p < .05$ **$p < .01$ ***$p < .001$ (two-tailed tests)

ability of timely graduation declines by 34 percent as a result of a low-birth-weight birth and increases by 6 percent for a one-unit increase in the income-to-needs ratio.

The fixed-effects model in Table 2 examines the question under a "stricter" model—sibling comparisons. In this framework, the effect of being born of low birth weight is dramatic. A low-birth-weight child is substantially less likely to graduate from high school by 19 years of age, with the probability of graduation reduced by 74 percent, as compared with his or her siblings. Income does not relate significantly to this long-term outcome in the fixed-effects framework presented here. However, our income variable essentially accounts for variations in income within the family (i.e., from one sibling's early childhood to that of the next sibling to the degree that they do not overlap) and not for variations in income across families. Thus, the lack of an observed effect does not preclude the possibility that income in early childhood plays an important role in the educational attainment process.

As a final word of caution, we note that low-birth-weight status may act as a proxy for unobserved factors within a family—for example, the social stigma that a low-birth-weight child may suffer at the hands of his or her family. It may not be the physiological effects of low birth weight that give rise

to slower educational progress; instead, it may be the social dynamics within the household that may, for example, allocate resources away from such a child. It may also be that low birth weight serves as a proxy for some other congenital anomaly that results in the observed deficiencies in educational attainment or other social conditions surrounding that individual's birth. These cautions notwithstanding, by invoking a fixed-effects framework, we have eliminated the confounding effects of many unobserved factors that exist among families.

DISCUSSION

This study helps to answer more definitively several questions regarding the relationship between socioeconomic factors and birth weight. First, it is not clear that additional dollars spent during the gestational period would significantly reduce the likelihood of low-birth-weight infants. Rather, the analysis suggests that the parents' own birth weight history—which is usually not controlled in studies of the effect on socioeconomic conditions on low birth weight—may be generating a spurious effect. A mother or father having been low-birth-weight themselves is associated with a huge increase in the probability that their child will be born at a low birth weight—by roughly four-fold and six-fold, respectively.

Second, this research extends the horizon of the effects of low birth weight well beyond the previous age limitations found in the literature. Traditionally, low-birth-weight babies were followed for several years. These studies found detrimental effects on the health and cognitive development of low-birth-weight children, but usually without adequate controls for potentially biasing unobserved characteristics. A few recent studies found that the consequences of low birth weight may extend to adult health and cognitive ability, although controls for cofactors in these studies were limited (Rich-Edwards et al. 1997; Sorensen et al. 1997). The present study goes further, to show that these consequences have a lasting impact on individuals' ultimate educational attainment, *net of socioeconomic status*, whether factored out through controls in a logistic regression framework or mother-fixed-effects models. Within the logistic framework (Model 3 in Table 2), we find that low-birth-weight status is associated with a dramatic decrease—by 34 percent—in the probability of graduating from high school in a timely fashion.

This finding reveals an intergenerational loop of social inequality and low birth weight, inserting biology into the debate over intergenerational poverty in a way that differs from how it has been conceived of within the health and poverty literature. Much work has assumed that poverty causes ill health. Causality may, in fact, work in the opposite direction of this assumption: Biological health at infancy affects development, which, in turn, affects socioeconomic status—producing the same observed intergenerational cycle of poverty and ill health. The findings here also support the findings of the British report mentioned earlier: Circumstances that occur around birth can have a lasting impact on outcomes measured even 19 years later, net of all of the common experiences of siblings in those intervening years.

It is important to keep in mind, however, that even in our within-family framework, our predictor variables may be acting as proxies for other more complicated dynamics and that there may be reverse causation affecting the findings presented here. For example, the transitions between births—from young to old maternal age and among various income levels—are all tied together as part of larger life transitions. Therefore, the exact causal mechanisms linking these indicators to health and educational outcomes remain unclear. Future researchers may want to investigate how low-birth-weight children end up disadvantaged educationally when compared with their siblings—is it through health problems, slowed cognitive development, or some other mechanism? A useful data set for this endeavor would be the National Longitudinal Survey of Youth mother-child file or the new Child Development Supplement to the PSID. These data sets make up for what the PSID main file lacks in terms of indicators of cognitive development and child health; they also contain multiple siblings. However, these data sets were not appropriate for the present analysis because the children for

whom birth weight is measured are too young to have reached a socioeconomic transition such as high school graduation. In a few years, however, some of the early NLSY children will reach adulthood, allowing researchers to build cumulative models of the effects of low birth weight on developmental and attainment measures. We encourage researchers to pursue this line of inquiry.

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