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Low birth weight and childhood health: the role of maternal education

Melissa L. Martinson, PhD [a,*], Kate H. Choi, PhD [b]

[a] University of Washington, School of Social Work, Seattle
[b] Department of Sociology, University of Western Ontario, London

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ABSTRACT

Purpose: Low birth weight (LBW) is associated with myriad health and developmental problems in childhood and later in life. Less well-documented is the variation in the relationship between LBW status and subsequent child health by socioeconomic status—such as education levels and income. This article examines whether differences exist in the relationship between LBW and subsequent child health by maternal education.

Methods: We used data from the 1998–2017 National Health Interview Survey to estimate multivariate logistic regression models to determine whether the association between LBW and subsequent child health as measured by general health status, developmental disability, and asthma diagnosis differed by maternal education, net of differences in children's sociodemographic factors, family background, and medical access.

Results: The negative association between LBW and subsequent health was typically weaker for children of mothers with less than high school education than it was for children of mothers with higher levels of education.

Conclusions: The findings on the enduring impact of LBW status on child health for all children, especially those born to mothers with higher levels of education, suggest that all children born LBW should be provided appropriate medical and support services to reduce the lifelong repercussions of poor health at birth.

Introduction

Being born low birth weight (LBW) is an important predictor of life circumstances in the United States and is associated with myriad health and developmental problems in childhood and later life [1,2]. In addition to these health impacts, LBW status also has lasting negative impacts on human capital formation and economic life chances [3], which can heighten the overall disadvantage of LBW children. Children born to families with lower education, income levels, and occupational status are significantly more likely to be born LBW, and these disparities in LBW are thought to play a major role in health inequality throughout the childhood and later life course [4], creating a complicated picture of the relationship between socioeconomic status (SES) and health disadvantage.

Less well-documented is the variation in the relationship between LBW status and subsequent child health and well-being by family SES—measured by education, occupational status, and income. The few studies on this topic have yielded mixed accounts. Using data from the British National Child Development Study of infants born in 1958, Currie and Hyson [5] found that the association between LBW and self-rated health during adulthood is weaker for children born to mothers with higher levels of education and occupational strata. Whether this pattern persists outside of the United Kingdom and for children of other birth cohorts is largely unknown. Also worth noting is that studies that have focused on the influence of LBW on cognitive function in childhood have also found that family income does not significantly moderate the relationship between LBW and cognitive development [6,7].

Parents in distinct social strata have varying capacities and resources to respond to a child's needs [8]. They may also respond to and invest in children born with low and high health endowments

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* Corresponding author. University of Washington, School of Social Work, 4101 15th Ave NE, Seattle, WA 98105.
E-mail address: melmart@uw.edu (M.L. Martinson).

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differently. Not only do these investment patterns have substantial implications for the future health of children born LBW but also they may create differentials in what being born LBW and other poorer health endowments mean for the life chances of individuals born to different social strata. Therefore, health economists and social demographers have long been interested in whether parenting behavior—parental investments in particular—can mitigate (or exacerbate) the adverse long-term consequences of being born with a poor health endowment [9]. Like the research on different types of SES and education disparities in the association between LBW on subsequent health and well-being, this body of work also offers divergent accounts. Most studies on this topic have shown that parents' investment choices most often reinforce the disadvantaged life chances of LBW children [9,10]. That is, irrespective of maternal education or family income, parents invest less time and resources in LBW children than they do in children born with normal birth weight (NBW)—usually a twin or sibling [9,10]. This is true for a variety of parental investments, including breastfeeding, well-baby visits, immunizations, and preschool attendance.

A handful of demographic studies, however, predicted the opposite. Hsin [11] used time diary data from the Child Development Supplement of the Panel Study of Income Dynamics to show that mothers without a high school (HS) diploma spend less time with LBW children than they do with NBW children, but the reverse is true for mothers with at least an HS diploma. Restrepo [12] used data from the National Longitudinal Survey of Youth - Child and Young Adult and found similar patterns for parental investments in time and goods using the Home Observation for Measurement of the Environment assessment. Arguably, the latter studies have suggested that in doing so, mothers with less education exacerbate (or maintain) differences between LBW and NBW children; whereas, mothers with higher levels of education "even things out" among offspring with differential health endowments at birth.

Taking advantage of the large sample from the National Health Interview Survey (NHIS), we examined whether the relationship between LBW and child health at ages 2 to 11 differed by maternal education. We focused on three important child health outcomes known to be related to LBW and maternal education level and previously used in studies examining the relationship between LBW and child well-being [13–17]: parent-rated overall child health, developmental disability, and asthma diagnosis. As far as we know, two of these outcomes (i.e., developmental disability and asthma) have never been studied previously for any age. Overall health status has been the subject of study for Currie and Hyson [5], but their focus was self-rated health in adulthood at age 33 for a British cohort born in 1958.

Based on findings from the health disparities and parenting behavior literature, we conceptualized two competing hypotheses for the potential moderating effect of maternal education on the relationship between LBW and subsequent child health. Under hypothesis 1, LBW children will have worse subsequent health than NBW children, and the relationship between LBW and subsequent health will be the same regardless of maternal education level. This scenario is possible if (1) LBW children born to mothers in one educational group do not have substantially worse infant and childhood health (i.e., poorer health endowments) than LBW children born to mothers in other educational groups and/or (2) mothers in all educational groups respond similarly in terms of parental investment strategies to the health challenges of LBW infant [9,10]. Under hypothesis 2, the relationship between LBW and subsequent health will be weaker for children born to higher educated mothers than for children born to less-educated mothers. This scenario is possible if (1) LBW children born to mothers with lower levels of education have poorer health endowments than LBW children born to mothers with higher levels of education and/or (b) less-educated mothers are less willing or have fewer resources to devote to their children with poorer health endowments [11,12].

Materials and methods

Data

We used data from the Sampled Child Core Questionnaire of the Integrated Public Use Microdata (IPUMS) files of the 1998–2017 NHIS. The NHIS is a large, nationally representative cross-sectional survey collecting information on health outcomes, health care access, and known health determinants in the United States [18]. We relied on surveys collected after 1998 because that year was the first time the NHIS asked about the relationship between the proxy respondent and the randomly sampled child [18]. This variable allowed us to restrict our sample to children whose health conditions were reported by a biological parent. Arguably, biological parents have a better understanding of a child's health than other adults in the household. Biological parents are also less likely to be vulnerable to recall bias for children's birth weight.

The Sample Child Core Questionnaire of the 1998–2017 NHIS was well-suited for the present analyses for several reasons. First, it asked a knowledgeable adult in the household (in this case a parent) to provide retrospective reports of a randomly selected child's birth weight. Second, the pooled NHIS is large and provided sufficient numbers of LBW children for us to stratify this sample by maternal education level. Third, it asked respondents to provide reports about a wide array of health outcomes (e.g., developmental outcomes, asthma, parent-rated overall health) for a randomly selected child in each household. Finally, it collected information on several risk factors of both LBW and subsequent child health, including parent's sociodemographic characteristics and health care access.

Sample

Our analyses relied on the sample of children between ages 2 and 11 living with their biological/adoptive mothers without missing information on key covariates. (Starting in 2013, the NHIS did not distinguish children living with their biological mothers from those living with their adoptive mothers. It is, however, noteworthy that less than 2% of children residing with biological/adoptive mothers between 1998 and 2012 did so with adoptive mothers, which implies that less than 1% of our sample is living with adoptive parents.) We focused on early and middle childhood because health patterns by SES are different among children and adolescents [19], and to be consistent with previous studies on LBW and child well-being that focused on this age group [6,11,12]. We also restrict our sample to mothers who are between the ages of 20 and 44 at the age of birth. The lower age bound restriction was imposed to ensure that we are not right censoring maternal prospects for completion of HS. The upper age bound was imposed to reduce the number of adoptive mothers after 2012. Due to cross-national differences in educational expansion, immigrant mothers without a HS diploma may possess unmeasured characteristics that are vastly different from US-born women with comparable levels of education. To account for these differences, we excluded children born to immigrant mothers in our primary analyses. These restrictions yielded a sample composed of 66,782 children, 5387 (or 7.8%) who are LBW.

Measures

Children's health was our outcome of interest. We focused on three child health outcomes—*general health status, disability, and asthma diagnosis*—known to be related to birth weight and used in

previous research on the impact of LBW on subsequent child health [17]. First, the NHIS asked respondents (i.e., a parent in our study) to rate the *general health status* of the randomly selected child: poor, fair, good, very good, or excellent. We categorized poor, fair, and good health as "poorer overall health" and very good and excellent health as "better health" [17,20]. In sensitivity analysis, we found that demarcating differences exist between those who report very good/excellent health and those who report worse health, but very good and excellent health behave similarly, as do poor, fair, and good health. Second, the measure of any *developmental disability* distinguished children with a developmental disability from those who do not have one. Children had a developmental disability if they have ever been diagnosed with ADHD, autism, cerebral palsy, intellectual disability, learning disability, or any other disability; are hearing impaired; or have seizures, stammered, or stuttered in past 12 months [15,17]. Our operationalization of this outcome variable is consistent with that used in prior research that that demonstrated that LBW was a risk factor for these developmental disabilities [15,21,22]. Finally, children were coded as having *asthma* if they were ever diagnosed with asthma or were told they had asthma. Asthma prevalence is markedly higher among LBW children than NBW children [14].

Low birth weight

Using information obtained from retrospective reports, we defined *LBW* as births when an infant weighed less than 2500 grams and NBW as when an infant weighted at least 2500 grams. Note that parents' recollection of birth weight is subject to extremely low recall bias [23–25].

Maternal education

We classified mothers into four categories according to their levels of education: (1) those without an HS diploma, (2) those who graduated from HS, (3) those with some college education, and (4) those with a college bachelor's degree or higher. Research shows that parental education is a strong predictor of child well-being and health, the amount of resources available to invest in children, and parents' investment strategy in response to their children's health endowments [8,26]. Supplementary analyses revealed that using the highest parents' education rather than maternal education yielded the same results.

Our models controlled for several potential risk factors for birth weight [15,16]. They were mother's age at birth, mother's race/ethnicity (non-hispanic (NH) white, NH black, Hispanic, NH Asian), and children's sex (female vs. male). It is important to note that these factors are time-fixed, so they would not change between the time of birth and date of interview (i.e., 2–11 years later). We also controlled for children's family background characteristics at the time of the survey, which have been identified as risk factors for poor childhood health that are distributed unequally by maternal education level, such as mother's marital status (single, cohabiting, married, separated/divorced/widowed), current poverty status (under the official poverty threshold, 100%–199% of the official poverty threshold, greater than 200% of the official poverty threshold, or missing), number of siblings in the home, and current children's insurance coverage (none, private, public, or missing). All models accounted for children's age as a continuous variable.

Analytical strategy

In our analysis, we determined whether or not the association between LBW and children's subsequent health varies according to maternal education. We first present the rates of LBW by maternal education. We then estimate multivariable logistic regression models were used to determine whether child health disparities by maternal education and LBW status persisted after we controlled for children's family background, maternal sociodemographic characteristics, and medical access at the time of the survey (as detailed in the measures section). We estimated interaction terms by maternal education and LBW status to compare the magnitude of health disparities by LBW status across categories of maternal education. We included 95% confidence intervals to test for

Table 1
Percentage of low birth weight by maternal education

Maternal education	% LBW	[95th CI]		Base N
Less than HS	11.4	10.5	12.4	5422
HS graduate	8.6	8.1	9.1	15,728
Some college	7.7	7.4	8.1	24,518
College graduates	6.7	6.3	7.1	21,114

Sample: Children between the ages 2 and 11 born to U.S.-born mothers.
Analyses are weighted. Counts are not weighted.
1998–2017 NHIS.

Table 2
Sample characteristics by maternal education and birth outcomes (col %)

	LBW	NBW
	5387	61,395
Education		
Less than HS	10.2	6.7
HS graduate	24.9	22.5
Some college	35.7	36.2
College graduate	29.2	34.6
% Girl	53.9	48.5
Child's age		
Mean	6.2	6.4
SD	2.9	2.9
# of Siblings		
Mean	1.1	1.1
SD.	1.1	1.0
Region		
Northeast	16.6	17.7
Midwest	25.7	26.5
South	42.8	37.3
West	14.9	18.5
Mother's age at birth		
Mean	29.2	29.0
SD	6.0	5.5
Mother's race		
NH white	67.7	78.3
NH black	22.5	12.4
Hispanic	8.8	8.3
NH Asian	1.0	1.0
Marital status		
Never married	14.6	9.1
Married	65.5	74.0
Cohabited	7.2	6.0
S/W/D	12.8	10.9
Employment status		
Unemployed	4.8	3.6
Working	66.9	69.9
Not in labor force	28.3	26.5
Current Poverty		
Below poverty line	17.1	10.9
100%–199% of the poverty line	19.4	15.8
200 + of the poverty line	54.1	63.0
Missing	9.4	10.3
Current insurance		
None	13.7	11.8
Public	17.9	11.7
Private	65.5	73.9
Missing	2.9	2.7

Sample: Children between the ages 2 and 11 born to U.S.-born mothers.
Analyses are weighted. Counts are not weighted.
S/W/D = separated, widowed, and divorced.
1998–2017 NHIS.

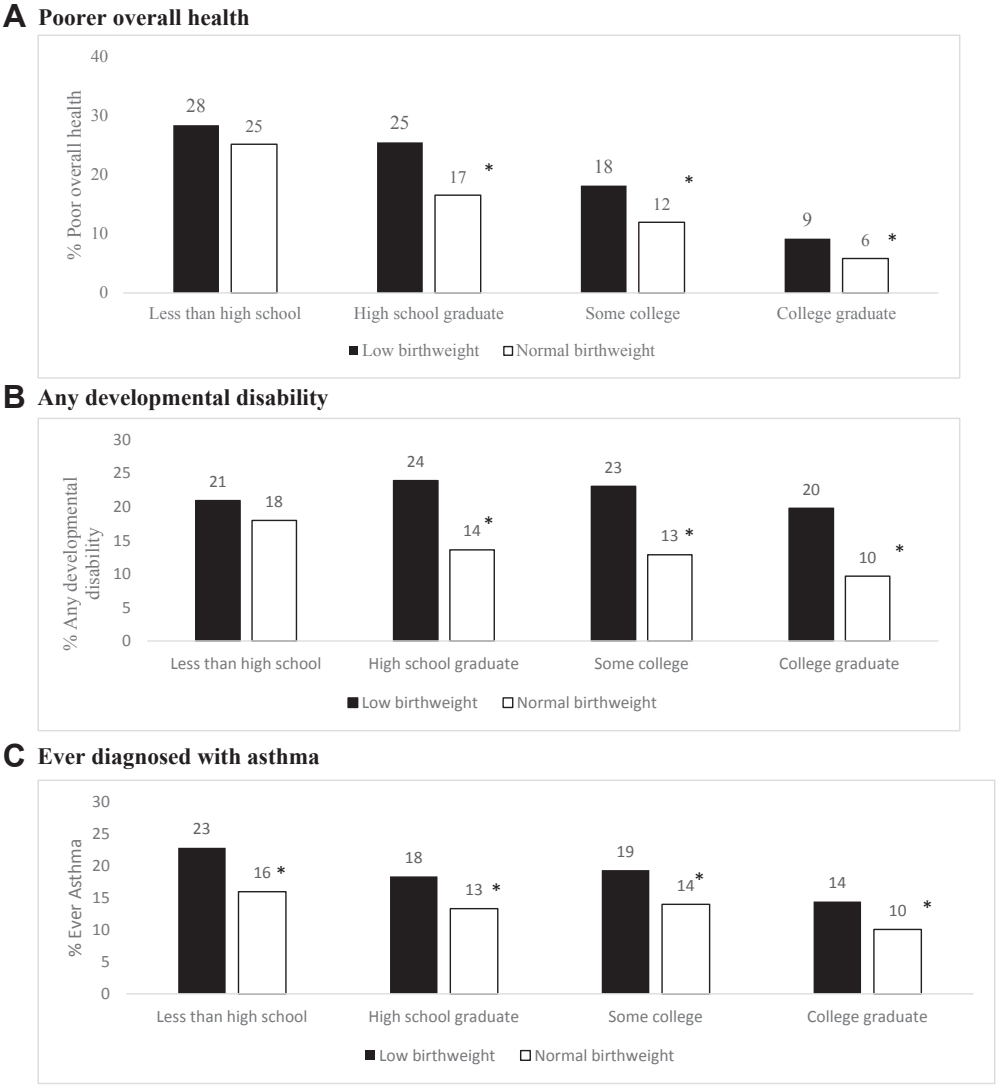

Fig. 1. Health disparities by LBW status and maternal education. (A) Poorer overall health. (B) Any developmental disability. (C) Ever diagnosed with asthma. Sample: Children between the ages 2 and 11 born to U.S.-born mothers. Percentages are weighted. *Differences by LBW status are significant at the 5% level.
1998–2017 NHIS.

statistical significant. All analyses were weighted and estimated using svy commands in Stata SE 15 to account for the complex and multiyear sampling design of the NHIS.

Results

Descriptive results

Table 1 presents the rate of LBW by maternal education. It shows what has been well established in the LBW disparities literature; higher levels of education are protective against LBW [27]. Demarcating differences in rates of LBW are observed between children of mothers with less than an HS diploma and children of mothers with at least an HS diploma.

Table 2 compares the family background and sociodemographic characteristics of children according to their LBW status. LBW children were less likely than NBW children to live in two-parent households and to have private insurance coverage. LBW children were more likely than NBW children to live in poverty and to have a NH black mother.

Figure 1 documents variations in unadjusted rates of poorer overall health, disability, and asthma diagnosis by birth weight status and maternal education. In general, LBW children were significantly unhealthier than NBW children in each maternal education category. For example, 25% of LBW children versus 17% of NBW children born to female HS graduates reported having poorer overall health. The only exception was for rates of poor overall health and disability among children born to mothers without an HS diploma. Our results also showed that children born to mothers with lower levels of education were generally unhealthier than those born to mothers with higher levels of education. For example, 18% of NBW children born to mothers without an HS diploma reported having a developmental disability compared with 14% of children born to HS graduates and 10% of children born to college graduates. The only exception to this overall pattern was observed for LBW children born with developmental disability. Among LBW children, rates of developmental disability by maternal educational were not significantly different.

Multivariable results

Table 3 presents the results of multivariable logistic regression models predicting the odds of having poorer overall health, any developmental disability, and being ever diagnosed with asthma.

Table 3
Logistic regression models predicting odds of having poorer health, any developmental problems, and having ever been diagnosed with asthma

	Poor overall health				Developmental disability				Ever asthma			
	e^{β}		[95th CI]		e^{β}		[95th CI]		e^{β}		[95th CI]	
Birth weight (NBW)												
LBW	1.11	—	0.89	1.37	1.29	†	1.02	1.64	1.64	§	1.30	2.07
Maternal education (less than HS)												
HS graduate	0.77	§	0.71	0.85	0.82	§	0.74	0.91	0.94	—	0.85	1.05
Some college	0.59	§	0.54	0.64	0.85	§	0.76	0.94	1.07	—	0.97	1.19
College graduate	0.36	§	0.32	0.40	0.73	§	0.65	0.81	0.89	†	0.79	1.00
Maternal education * LBW												
LBW * HS graduate	1.39	‡	1.07	1.80	1.60	§	1.20	2.13	0.84	—	0.63	1.12
LBW * some college	1.32	‡	1.03	1.70	1.65	§	1.26	2.17	0.87	—	0.66	1.13
LBW * college graduate	1.41	‡	1.05	1.89	1.95	§	1.45	2.60	0.91	—	0.68	1.22
Child's age	1.05	§	1.04	1.06	1.18	§	1.17	1.19	1.11	§	1.10	1.12
No. of siblings	1.01		0.98	1.03	0.96	‡	0.93	0.98	0.94	§	0.91	0.96
Girl (boy)	0.83	§	0.79	0.87	0.46	§	0.44	0.49	0.64	§	0.60	0.67
Region (Northeast)												
Midwest	1.08	*	1.00	1.18	0.91	†	0.84	0.99	0.75	§	0.69	0.81
South	1.01	—	0.94	1.11	0.99	—	0.92	1.07	0.80	§	0.74	0.86
West	0.88	‡	0.80	0.96	0.76	§	0.70	0.83	0.75	§	0.69	0.82
Maternal age at birth	1.00	—	1.00	1.01	1.01	†	1.00	1.01	0.99	§	0.98	0.99
Mother's race (NH white)												
NH black	1.50	§	1.39	1.61	0.74	§	0.68	0.80	1.49	§	1.38	1.60
Hispanic	1.43	§	1.32	1.55	0.90	†	0.82	0.98	1.24	§	1.14	1.35
NH Asian	1.41	‡	1.09	1.84	0.64	‡	0.46	0.89	1.32	†	1.03	1.68
Mother's marital (married)												
Never married	1.17	‡	1.06	1.28	1.21	§	1.10	1.34	1.31	§	1.19	1.43
Cohabiting	1.30	§	1.17	1.43	1.34	§	1.21	1.49	1.17	‡	1.05	1.30
S/W/D	1.23	§	1.13	1.33	1.35	§	1.24	1.46	1.29	§	1.19	1.39
Mother's employment (employ)												
Not in labor force	1.12	*	0.99	1.26	1.32	§	1.17	1.49	1.07	—	0.94	1.21
Unemployed	1.03	—	0.97	1.10	1.17	§	1.10	1.25	1.02	—	0.96	1.09
Current poverty (below)												
100%–199% * poverty line	0.81	§	0.74	0.88	0.92	*	0.84	1.01	0.84	§	0.77	0.92
200*% poverty line	0.50	§	0.46	0.55	0.69	§	0.62	0.76	0.79	§	0.71	0.87
Missing	0.69	§	0.62	0.76	0.58	§	0.51	0.65	0.70	§	0.63	0.79
Current insurance coverage (private)												
None	1.15	§	1.06	1.24	1.12	‡	1.02	1.22	1.03		0.94	1.12
Public	1.25	§	1.14	1.36	1.54	§	1.40	1.69	1.24	§	1.13	1.35
Missing	1.18	†	1.00	1.38	1.39	§	1.20	1.62	1.03	—	0.88	1.20
Intercept	0.22	§	0.18	0.27	0.08	§	0.07	0.10	0.18	§	0.15	0.23

Sample: Children between the ages 2 and 11 born to U.S.-born mothers.
Analyses are weighted. Counts are not weighted. Reference categories are in presented in the parentheses.
S/W/D = separated, widowed, and divorced.
* $P < .10$.
† $P < .05$.
‡ $P < .01$.
§ $P < .001$.
1998–2017 NHIS.

Across the three outcomes, the risk of being unhealthy was lower for girls than for boys, younger children relative to older children, children with married relative to unmarried mothers, and children with private relative to public insurance. White children were less likely than nonwhite children to have poorer overall health status and receive an asthma diagnosis, but more likely to be diagnosed with a disability. The inclusion (or exclusion) of controls has little impact on variations in the association between LBW and subsequent child health; thus, we focus on the results from our full model. Nested models without controls are available on request.

LBW children were more likely than NBW children to have poorer overall health. Maternal education modified the relationship between LBW status and overall health. LBW children born to mothers without an HS diploma had 11% higher odds of having poorer overall health relative to their NBW counterparts. This difference was also statistically insignificant. The same differential was 32%–41% larger for children born to mothers with an HS education or more. Interestingly, among the subsample of children born to mothers with a HS education or more, maternal education did not modify the relationship between LBW status and poorer overall health. The results for any developmental disability were similar to those for poorer overall health. The only noteworthy difference was that disparities in odds of having a developmental disability by LBW status were more pronounced than disparities in odds of having poorer overall health status by LBW status.

Our results for asthma deviated somewhat from the results for poorer overall health status and any developmental disability. Like the other two outcomes, LBW children were more likely than NBW children to have an asthma diagnosis. Children born to female college graduates were less likely than those born to women without a college diploma to receive an asthma diagnosis. Yet, unlike the other two health outcomes, differences by maternal education were minimal among the subsample of children born to mothers without a college degree. Furthermore, maternal education did not moderate the relationship between LBW and asthma diagnosis.

We conducted several different sensitivity analyses that are available on request. First, we reran our analyses after having disaggregated sampled children into two groups: (1) young children (2–5 years) and (2) school-aged children (6–11 years). Second, we

conducted supplementary analyses where we included immigrants in our models and controlled for mother's nativity. Third, we also relied on alternate specifications of poor overall health and an alternate measure of asthma diagnosis (i.e., attack in the last 12 months). Our results were robust across these supplementary analyses.

Conclusions

The goal of our study was to determine whether the relationship between LBW and child health was moderated by maternal education. In addressing this question, we sought to contribute to the literature assessing whether differences in maternal education may alter the long-term consequences of health endowments at birth. Our results suggest that the relationship between LBW and child health did, in fact, vary by maternal education. Children with mothers with at least an HS diploma experienced better subsequent health than children with mothers without an HS diploma, but in contrast to our hypotheses, the negative association between LBW and subsequent health was typically weaker for children of mothers without an HS diploma than it was for children born to mothers with at least an HS diploma for poorer overall health and developmental disability. For asthma, however, the results support our first hypothesis that the relationship between LBW and subsequent health is similar across education categories.

Our results seemingly stand in contrast to research suggesting that mothers with higher levels of education do more to try to mitigate the adverse consequences of being born with low health endowments such as LBW by investing more in a LBW child than a NBW child [11,12]. However, our results may fit more closely with Datar et al's [10] finding that parents are more likely to invest in NBW children than LBW children, regardless of SES (both education and family income). Datar et al [10] used measures of investments that may resonate more for physical health (e.g., breastfeeding, well-baby visits, and immunizations) than the time-related investment measures used by Hsin [11] and Restrepo [12].

Sensitivity analysis suggested that the average birth weights of LBW infants born to mothers with different education levels are statistically the same, but NBW infants born to mothers with lower levels of education are smaller than NBW infants born to mothers with higher levels of education. As the average weight of LBW infants did not vary by maternal education, differences in average birth weight between LBW and NBW children born to mothers with lower levels of education are smaller than the corresponding difference for children born to mothers with higher levels of education (results available on request). Arguably, our results could partially be the product of the magnitude of differences in average weight by NBW status between children born to mothers with varying levels of education. Another potential explanation is this: given the fact that children born to less-educated mothers are more likely to have subsequent health and development problems overall, perhaps LBW is part of overall life disadvantages associated with markers of low SES [4]. This conclusion is in line with research that has examined the moderating influence of parental SES on the relationship between LBW and cognitive development [6,7]. However, notably, this finding applies for parent-rated poorer health and developmental disability, but not for asthma. Asthma may be more likely to be confounded by other factors: for example, quality medical care and a higher likelihood of diagnosis may dampen any education-related variation in the relationship between this health outcome and LBW as these factors are more available to high SES children than low SES children [28].

Our study is not without limitations. Due to the cross-sectional nature of the NHIS, we were unable to look at many factors, such as other indicators of SES and maternal health behaviors such as smoking at the time of birth. Second, as with most studies examining the association between birth weight and the prevalence of health conditions and disability, our sample consisted of surviving children [1,15,21,22]. Perhaps, the education-related disparities in the health consequences of LBW may exhibit instead as infant mortality rather than health problems in childhood. As with previous studies using the NHIS to evaluate LBW, we were unable to examine the role preterm birth may play on subsequent child health or examine variation for small for gestational age children [15,17,22]. Finally, the NHIS does not measure education at the time of birth, so our sample restriction may miss a very small number of mothers (approximately less than 5% of mothers without an HS diploma) who receive their General Educational Development after the age of 20 years.

Public health implications

Our results align with previous research demonstrating that health endowments at birth have important implications for health later in life, regardless of parents' education. Importantly, this study suggests that maternal education and the resources that come with it do not protect against the detrimental health impacts of LBW later in childhood. In fact, health disparities by LBW status are larger among children born to mothers with higher levels of education than for their peers born to mothers with lower levels of education. Yet, it is also worth noting that our findings also demonstrate that the greater propensity of disadvantaged children to be born with LBW relative to their more advantaged counterparts may be a key driver of health disparities by SES throughout the life course. These implications are in line with Link and Phelan's theory of fundamental causes, wherein SES influences health through both access to resources and the adaptation of the mechanisms that shape health inequalities over the life course and posits that health inequalities such as those presented here require significant policy changes to address societal inequality [29,30]. The findings also highlight the importance of effective social policies (e.g., visiting services and early childhood education programs) aimed at providing additional support to all expectant mothers, irrespective of their education or the amount of resources available to their families [31]. The findings on the enduring impact of LBW status for children of all educational and economic backgrounds suggest that all children born with LBW should be provided appropriate medical care to reduce the lifelong repercussions of poor health at birth.

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Appendix

Table A1
Sample restrictions with the number of cases excluded

Sample	N
All	1,885,672
Excluded	
Not in sample child core questionnaire	1,647,332
Parent is not the respondent	20,359
Not biological until 2012/not biological or adopted after 2012	15,419
Younger than 2 years or older than 11 years	93,859
Missing birth weight	5519
Missing information about poor overall health	16
Missing information about developmental disability	1096
Missing information about ever had asthma	81
Could not match with mother	156
Mothers were younger than 20 years or older than 45 years	8951
Missing: mother's education	303
Missing: mother's employment status	48
Missing: U.S.-born	59
Immigrant	24,717
Missing: mother's race	919
Missing: marital status	56
Subtotal: Excluded	1,818,890
Our analytical sample	66,782

Sample: Children between the ages 2 and 11 born to U.S.-born mothers.
Ns = not weighted.
1998–2017 NHIS.

Table A2
Predicted percentages of poorer health, any disability, and having been ever diagnosed with an asthma

	Low birth weight			Normal birth weight		
	%	[95th CI]		%	[95th CI]	
% Poor health						
Less than high school	16.0	13.3	18.6	14.7	13.6	15.8
High school graduate	16.9	14.9	18.9	11.8	11.2	12.4
Some college	12.9	11.4	14.4	9.2	8.8	9.7
College graduate	8.8	7.2	10.3	5.8	5.5	6.2
% Any developmental disability						
Less than high school	15.7	12.8	18.5	12.7	11.7	13.8
High school graduate	19.4	17.2	21.6	10.8	10.2	11.4
Some college	20.3	18.4	22.2	11.1	10.6	11.5
College graduate	20.4	18.1	22.8	9.7	9.2	10.1
% Ever asthma						
Less than high school	16.9	13.9	19.8	11.1	10.1	12.1
High school graduate	13.9	12.1	15.8	10.6	10.0	11.2
Some college	15.9	14.2	17.5	11.8	11.3	12.3
College graduate	14.2	12.2	16.2	10.1	9.6	10.5

Sample: Children between the ages 2 and 11 born to U.S.-born mothers.
Analyses are weighted. Percentages are computed using the coefficients presented in Table 3 and the distribution of sample characteristics for the subpopulation of normal birth weight children and children born to college graduates.
1998–2017 NHIS.

Table A3
Logistic regression models predicting odds of having poorer health, any developmental problems, and ever having been diagnosed with asthma using two and four categories of maternal education

	Poor overall health			Developmental disability			Ever asthma		
	eβ	[95th CI]		eβ	[95th CI]		eβ	[95th CI]	
Two categories of maternal education	—	—	—	—	—	—	—	—	—
Birth weight (NBW)									
LBW	1.11	0.89	1.37	1.29*	1.02	1.64	1.64‡	1.30	2.07
Maternal education (less than HS)									
HS graduate or more	0.62‡	0.57	0.68	0.82‡	0.74	0.90	0.99	0.90	1.10
Birth weight * maternal education									
LBW * HS graduate or more	1.38†	1.09	1.74	1.72‡	1.33	2.22	0.87	0.68	1.12
Four category of maternal education	—	—	—	—	—	—	—	—	—
Birth weight (NBW)									
LBW	1.11	0.89	1.37	1.29*	1.02	1.64	1.64‡	1.30	2.07
Maternal education (less than HS)									
HS graduate	0.77‡	0.71	0.85	0.82‡	0.74	0.91	0.94	0.85	1.05
Some college	0.59‡	0.54	0.64	0.85†	0.76	0.94	1.07	0.97	1.19
College graduates	0.36‡	0.32	0.40	0.73‡	0.65	0.81	0.89*	0.79	1.00
Birth weight * maternal education									
LBW * HS graduate	1.39*	1.07	1.80	1.60†	1.20	2.13	0.84	0.63	1.12
LBW * some college	1.32*	1.03	1.70	1.65‡	1.26	2.17	0.87	0.66	1.13
LBW * college graduates	1.41*	1.05	1.89	1.95‡	1.45	2.60	0.91	0.68	1.22

Sample: Children between the ages 2 and 11 born to U.S.-born mothers.
Analyses are weighted. Full model presented in Table 3. Reference categories are in presented in the parentheses.
* $P < .05$.
† $P < .01$.
‡ $P < .001$.
1998–2017 NHIS.