



Asthma and child behavioral skills: Does family socioeconomic status matter?



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ABSTRACT

Asthma is associated with poorer behavioral and psychological outcomes in children, yet little is known about whether and how the social stratification process affects the impacts of asthma on children's outcomes. Using data from the Early Childhood Longitudinal Study—Birth Cohort, this study considered the role of socioeconomic status in shaping the developmental consequences of children's asthma. Results showed that asthma was negatively associated with attention and social competence and positively associated with externalizing problem behaviors for children with low-educated mothers and children who lived in poor households. However, the adverse consequences of asthma disappeared for children with high-educated mothers and children who did not experience poverty. Additionally, the socioeconomic disparities were not fully explained by healthcare resources, family process, and exposure to environment risks and the disparities were found for both mild and severe cases. These findings suggest that, to fully understand the developmental consequences of illness in children, it is important to place socioeconomic status at the center of investigation.

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1. Introduction

Long-term illness is associated with lower levels of behavioral and psychological wellbeing in children. Past research shows that children with chronic health problems have more behavioral problems, lower levels of emotional wellbeing, and decreased levels of social competence (Gortmaker et al., 1990; Hysing et al., 2007; Hysing et al., 2009; Martinez et al., 2011; Parcel et al., 2012). The poor behavioral and psychological outcomes of ill children are often attributed to neurobiological disorders resulting from physical illness (Cutuli et al., 2010; Rachelefsky et al., 1986) or the influence of contextual and healthcare factors, including access to quality healthcare, family process, and social supports (Butz et al., 1995; Patterson and Blum, 1996; Wallander and Varni, 1989). While the focus on these biological and social mechanisms generates considerable insights into the processes through which physical illness translates to poor developmental outcomes in childhood, very little attention is paid to socioeconomic status [SES]—a fundamental social condition that deeply influences all aspects of individual health and

wellbeing—and its contribution to the differential consequences of illness in children.

This study focuses on a single chronic illness—asthma—as a case to highlight the role of socioeconomic inequality in shaping the developmental consequences of illness in children. Asthma is the most common and fastest growing chronic illness in children in the United States. The Center for Disease Prevention and Control [CDC] (2010) estimates that approximately 6% of children under the age of five have been diagnosed with asthma. Therefore, understanding the developmental consequences of asthma is important in its own right and highly relevant for policy. Furthermore, many clinical and epidemiological studies show that asthmatic children have higher levels of behavioral problems and that the impacts of such problems often increase with asthma severity (Cutuli et al., 2010; Calam et al., 2005; Rachelefsky et al., 1986). Yet, few explore socioeconomic disparities in developmental consequences of asthma. Finally, children's asthma is an ideal case for investigating how social stratification process shapes the developmental consequences of diseases because the prognosis of asthma depends heavily on parental management and successful management often depends on social circumstances.

The perspective proposed in this study, which emphasizes socioeconomic inequalities in disease consequences, complements the epidemiological approach in the current literature. Results from this study also provide important insights into secondary

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prevention efforts that aim to promote the behavioral skills and psychological wellbeing of asthmatic children.

2. The developmental consequences of asthma: a sociological perspective

Asthma is the most common chronic condition in young children in many developed countries including the United States (*The International Study of Asthma and Allergies in Childhood Steering Committee, 1998*). Early childhood asthma, while important in its own right and consuming enormous healthcare resources (*Bahadori et al., 2009*), can also affect children's development. Asthma can lower lung function in children which, in turn, reduces the oxygen supply to the rapidly developing brain in early childhood (*Bass et al., 2004; Covar et al., 2004*). The reduced availability of oxygen may result in behavioral and socioemotional problems. Medical studies also suggest that several medications for asthma can stimulate the central nervous system and cause change in children's behaviors and psychological conditions (*Haahtela et al., 1994*). Many observational studies have found significant associations between childhood asthma and children's behavioral outcomes, and the impact often is found to vary by severity (*Bender et al., 1988; Calam et al., 2005*). The importance of studying developmental consequences of asthma is further driven by the extensive research that links these early-life behavioral skills with a wide range of social outcomes, including educational attainment (*Claessens et al., 2009*), delinquency (*Coneus and Laucht, 2011*), and labor market success (*Caspi et al., 1998*). However, there are relatively few population-based studies that examine whether and how asthma influences developmental outcomes in the general population of young children. More importantly, even fewer population-based studies investigate the social process that may influence the development of asthmatic children.

Sociology distinguishes itself from the epidemiological paradigm by considering SES as the fundamental cause of inequalities in health (*Link and Phelan, 1995*). As social stratification system determines the distribution of resources and information, a persistent association between SES and health is created and maintained despite the advances of medical technology and substantial investments in public health. Although the bulk of the prior sociological works emphasizes socioeconomic disparities in health outcomes (e.g., *Link et al., 2008; Phelan et al., 2004*), its general tenets are applicable to understanding the consequences of illness. The idea that social stratification determines differential consequences of illness is further elaborated by Finn Diderichsen and his colleagues (*Commission on Social Determinants of Health (2007); Whitehead, & Diderichsen, 2002*). According to Diderichsen's model, socioeconomic position can modify the developmental consequences of illness like asthma because it relates to a number of broad mechanisms that influence children's development. Specifically, I argue that SES influences three broad mechanisms—healthcare resources, family process, and environmental risks—that connect asthma to poor developmental outcomes in children.

2.1. SES, healthcare resources, and disparities in consequences of asthma

Socioeconomic status yields heterogeneous healthcare resources, which affect individuals' access to healthcare and the quality of the services received. Not surprisingly, access to healthcare resources plays a central role in the discussion of the consequences of asthma. Children who have access to healthcare services show better asthma outcomes (*Halfon and Newacheck, 1993*). Aside from the access issue, the quality of the healthcare received may

determine the consequences of asthma. Prior research on chronic illness suggests that better healthcare services can facilitate the control and management of chronic illness, including asthma (*Lozano et al., 1995; Lutfey and Freese, 2005*). Furthermore, medical institutions that serve the needs of high SES patients are often more responsive to the patients' conditions and emotional wellbeing (*Lutfey and Freese, 2005*). The same may well apply to children's asthma.

However, children from low SES families are less likely to have health insurance coverage, and thus have limited access to healthcare services (*Urban Institute, 2005*). Despite the recent expansion of public insurance programs, a non-trivial proportion of children remain uninsured (*Angier et al., 2013*). Among children covered by public insurance, approximately one-quarter were no longer enrolled in the program twelve months later (*Sommers, 2005*). The high dropout rate of children from public health insurance hinders the continuity of treatment and the development of a management plan for asthmatic children (*National Heart, Lung, and Blood Institute, 2007*), which can also be related to the behavioral skills and psychological wellbeing of asthmatic children.

2.2. SES, family process, and disparities in consequences of asthma

Socioeconomic status shapes family process, which has significant consequences for the development of asthmatic children. Among the many aspects of family process, maternal psychological resources and home environment are particularly important for child wellbeing. Decades of research has demonstrated strong associations between maternal depression and home environment and children's behavioral skills and psychological wellbeing (*Belsky, 1984; Conger et al., 2002; Maccoby, 2000; McLeod and Nonnemaker, 2000*). Extant evidence suggests that the role of family process is more important for the wellbeing of chronically ill children. Because physical illness decreases a child's energy, limits the child's activities, and generates pain, a supportive home environment and parental warmth can substantially mitigate the negative influence of illness on the child's daily life and promote the child's behavioral skills and psychological wellbeing (*Kaugars et al., 2004*). Distress in the family and parenting disorganization can be obstacles to medical adherence and the successful management of asthmatic symptoms, which leads to less optimal behavior and psychological outcomes (*Christiaanse et al., 1989; Kaugars et al., 2004*). The significance of family process on ill children's wellbeing has also been demonstrated in a randomized control trial. *Chernoff et al. (2002)* shows that interventions aim to reduce parenting stress and promote a positive home environment for families with an asthmatic child have demonstrated significant improvements on children's behavioral and psychological outcomes.

Socioeconomic status creates an unequal distribution of these important family resources among asthmatic children. Children from high SES families live in more developmentally beneficial home environments as compared to their low SES counterparts (*Davis-Kean, 2005; Kalil et al., 2012; Lareau, 2003*). In addition, because managing asthma in one's child is often time-consuming and stressful, asthma can lead to the decline of maternal psychological wellbeing and the home environment. Prior research shows a strong association between children's asthma and increased parental depression and parenting stress, and decreased family functioning (*Carson and Schauer, 1992; Cohen, 1999; Hamlett et al., 1992*). This often leads to a decline in emotional support and an increase in harsher parenting. Even worse, because high SES families have more resilient resources to buffer the impacts of the children's illness on the family process, the negative influence of the children's illness on the family process are expected to be found

in low SES families disproportionately (Hogan, 2012). This further widens the socioeconomic gaps of family resources among asthmatic children. Finally, high SES parents may have greater levels of learned effectiveness that help them better utilize information to mitigate the influence of asthma on their children's outcomes and seek better treatments and management strategies (Mirowsky and Ross, 2003). Taken together, SES yields differences in family process that are of significant consequences for the behavioral and psychological outcomes of asthmatic children.

2.3. SES, environmental risks, and disparities in consequences of asthma

Lastly, socioeconomic status ties to children's exposure to environmental risks. A large literature has documented that children from low SES families are more likely to live in poor environment that has greater exposure to toxic substance and is less conducive for children's development (Evans, & Kantrowitz, 2002). For example, because SES negatively correlates with tobacco use, children from low SES families are more likely to expose to cigarette smoke at home as compared to their high SES peers (Cook et al., 1994; National Center for Health Statistics, 1991). Low SES parents may also be less aware of the harms of smoking (Siahpush et al., 2006) and are less likely to change their smoking behaviors at home. Additionally, children from economically disadvantaged families often live in neighborhoods with toxic wastes (Institute of Medicine, 1999) and hazardous pollutants (Calderon et al., 1992). Such neighborhoods, often located in the inner city, are also more dangerous and lack of social support and critical social infrastructure (Sampson et al., 2002).

All these environmental risks can affect not only children's chance of developing asthma and but also the developmental consequences of asthma. Maternal smoking has been linked to behavioral problems in children in early life (Chen, 2012; Weitzman et al., 1992). Neighborhood disorder is associated with children's behavioral problems and psychological well-being (Sampson et al., 2002). In this ways, low SES children with asthma live in a disadvantaged environment that can exacerbate the consequences of asthma on their development. This suggests that environmental risks can be another potential mechanism that generates SES disparities in the developmental consequences of asthma in children.

The illustration of these mechanisms highlights the role of SES as an umbrella factor that influences a multitude of pathways that determine the developmental consequences of asthma. As such, I expect to observe socioeconomic gradients in the behavioral and psychological consequences of asthma. Yet, they are by no means the only mechanisms that are affected by SES. SES may influence numerous other pathways that contribute to the poor developmental consequences of asthma. Because these mechanisms are the focus in the discussion of the relationship between SES and child outcomes and they are subjected to policy and program interventions, this study concentrated on these three mechanisms.

3. Methods

3.1. Early Childhood Longitudinal Study—Birth Cohort

This study used the Early Childhood Longitudinal Study—Birth Cohort (ECLS-B), a nationally representative sample of approximately 9000 children born in the United States in 2000. Interviews were conducted with the families when the children were nine months old (2001), two years old (2003), during the year they attended preschool (2005), and during their year of kindergarten

(2006). The ECLS-B data are ideal for this study for a number of reasons. First, this is a nationally representative study, which allows for the investigation of the relationship between asthma and child behavioral skills across socioeconomic strata. Second, the data include repeated measures of child developmental outcomes. This enables the tracing of changes in the children's development over time. Finally, the data refer to children who were born relatively recently; thus, the results have contemporary relevance and important implications for policies and practices that address the needs of asthmatic children.

This study used the last two waves (the preschool and kindergarten waves) of the data because the ECLS-B first began collecting information on child behavioral skills in the preschool year. Only approximately 75% of the children were enrolled in kindergarten in the fall of 2006; the other 25% of the original sample (approximately 2600) were not eligible for the 2006 fall survey. Among the 6250 eligible children, 5750 participated in the survey (numbers were rounded to the nearest 50 because of the requirement of the restricted-use license agreement of the ECLS-B data). I employed multiple imputation (MI) to reduce the bias that can result from missing data. MI involves using the Monte Carlo technique to replace missing values with the estimated distribution of the missing value conditional on the values of other observed variables. In contrast to single imputation, which replaces each missing value with one estimate, multiple imputation employs repeated imputation inference to create several estimated values that together constitute the estimated distributions of the missing variables conditional on the covariates, yielding several complete datasets. In this way, the combined results produce better estimates of the missing values (Allison, 2001). I used all of the dependent and independent variables, which are described in the following section, and generated ten imputations.

3.2. Measures

3.2.1. Child behavioral skills

Beginning in the preschool year of the survey, mothers were asked to rate their children's behaviors and psychological wellbeing using the modified version of the Preschool and Kindergarten Behavioral Scales. Mothers rated children's behaviors based on a five-point scale on which a higher value indicates a higher frequency of occurrence (i.e., 1 = almost never, 2 = less than half of the time, 3 = about half of the time, and so on). I relied on 15 items that appeared in both the preschool and kindergarten year questionnaires. An exploratory factor analysis revealed the following three dimensions of child psychological wellbeing: (1) attention, (2) externalizing problem behaviors, and (3) social competence. A total score was obtained by summing the values of all of the items within each dimension. These totals were then standardized based on the final analytic sample to facilitate interpretation and comparison across behavioral outcomes.

The use of mothers' reports of behavioral skills raises concerns about the validity of the measures. If mothers are unaware of their children's experiences, their reports may substantially differ from those obtained from the children's caregivers or teachers. In contrast to these concerns, prior research found significant agreement between mothers' and teachers' reports of child behaviors using the Child Behavior Checklist (Stanger & Lewis, 1993). In addition, extant evidence suggests that mothers are more accurate informants regarding young children's behaviors, such as hyperactivity and inattention, than other caregivers or teachers (Fox and Henderson, 1999). Finally, not all children had teachers or caregivers who reported data in the preschool wave. Thus, mothers' reports appear to be reasonable proxies for the purpose of this study.

3.2.2. Socioeconomic status

This study operationalized SES as maternal education and household poverty history. Maternal education was based on the mother's highest level of education in the preschool year survey. There were four categories: less than high school, high school, some college, and college or more. Approximately 13% of mothers were enrolling in a course at a school, college, or university at the time of the interview. The education of these mothers might have increased by the kindergarten wave of the survey. To address this issue, I used the highest degree completed if they received a degree between the preschool and kindergarten waves of the survey (approximately 3%). Otherwise, mothers were assigned to the highest level of education completed by the preschool wave, irrespective of their course enrollments.

Household poverty history was derived via family's poverty status. At each wave, mothers reported their family income and household size, which were used to generate the family's poverty status based on that year's federal poverty level. These variables were then transformed into a three-category variable of household poverty history: (1) long-term poverty, defined as being under the poverty line throughout the study, (2) short-term poverty, defined as being under the poverty line in at least one wave of the survey, and (3) never being in poverty, defined as being above the poverty line throughout the study.

3.2.3. Childhood asthma

In the preschool and kindergarten waves of the survey, mothers were asked to report children's asthma diagnoses and conditions. The interviewers first asked the mothers whether their children had been diagnosed with asthma by a doctor or health professional since the previous interview. If the mothers answered in the affirmative, they were then asked whether their children had been hospitalized due to asthma for at least one night. The key explanatory variable, asthma diagnosis, was coded as one if a mother reported that the child had been diagnosed asthma and zero otherwise.

3.2.4. Family process

Measures of family process included positive parenting behaviors, parenting stress, and maternal depression. Positive parenting was measured by three questions derived from the Home Observation for Measurement of the Environment questionnaire (Bradley and Caldwell, 1984). At each phase, the mother was asked to report the frequency with which she read books to the child, sang songs with the child, and told stories to the child in a typical week using a four-point scale that ranged from "not at all" (1) to "everyday" (4). I created a positive parenting index by summing and standardizing the items ($\alpha = 0.57, 0.54$). This index served as a proxy for parenting quality and attentiveness. The measure of parenting stress was based on five items from a modified version of the Parenting Stress Index (Abidin, 1983). The mother reported whether she agreed or disagreed with each statement using a four-point scale that ranged from "strongly agree" to "strongly disagree." To obtain a parenting stress index, I summed values across all items and standardized them ($\alpha = 0.78, 0.79$). Lastly, maternal depression was measured with the twelve-item version of the Center for Epidemiological Studies Depression Scale (CESD). The maternal depression scale score was created by summing all of the items and standardizing them ($\alpha = 0.89, 0.90$). These scales were widely used in large-scale surveys and studies of child health and development and were strong predictors of child behavioral outcomes (Cummings and Davies, 1994; Deater-Deckard, 1998; Mott, 1999; Petterson and Albers, 2001). Together, these scales together capture several key aspects—such as cognitive stimulation, parenting quality, parental

emotional resources—of family environment (Kendrick et al., 2000).

3.2.5. Healthcare resources

In each wave of the survey, mothers were also asked to report children's health insurance coverage. The interviewers first asked the mothers whether their children were currently covered by a health insurance plan and the type of plan (i.e., private health insurance or public health insurance programs such as Medicaid). If the mothers reported currently no health insurance coverage for the children, they were then asked to report the length children without health insurance since the last interview. Based on the information, I generated two variables to capture children's healthcare resources. The first is a dummy variable indicating whether children were covered by a private health insurance plan as a proxy for high quality healthcare. The second is the months without health insurance coverage since the last interview to capture impact of lacking access to healthcare and medical services.

3.2.6. Environmental risks

For each wave of the survey, mothers were asked whether they smoked in the house. I used the information to create a dummy variable of maternal smoking at home. In addition, the dataset included information of residency location. Since neighborhoods in the inner city were more likely to have poor environmental conditions, I generated a dummy indicator of urban residency which was coded one if the respondent lived in a metropolitan area defined by the Census and zero otherwise. Finally, despite the survey did not have direct measures of neighborhood environment, it asked mothers to report their perception about the neighborhood safety. Given that disordered neighborhoods tend to have worse environmental conditions and poor infrastructure (Evans, & Kantrowitz, 2002; Sampson et al., 2002), neighborhood safety can be a reasonable indicator of the overall social and physical environment of the neighborhood. As such, I created a dummy variable which was coded one if mothers perceived the neighborhood as unsafe and zero otherwise.

3.2.7. Covariates

This study controlled for the children's ages, number of siblings, family structure, and maternal employment.

3.3. Analytic strategy

With the longitudinal data of ECLS-B, this study employed individual fixed-effects models to account for unobserved heterogeneity. The individual fixed-effects model minimizes the bias due to unmeasured confounders by predicting changes in child behavioral outcomes from changes in the explanatory variable and holding time-invariant, individual-level characteristics as fixed. As such, it eliminates the impacts of individual-level, time-invariant, unobserved confounding variables. The following equation describes the individual fixed-effects model where Y_{it} indicates the i th child's outcome at time t , $Asthma_{it}$ indicates the i th child's asthma diagnosis at time t , $Covariates_{it}$ indicates the time varying covariates, Fix_i indicates time-invariant individual-level characteristics, and SES refers to indicators of family socioeconomic status.

$$Y_{it} = \alpha + \beta Asthma_{it} + \gamma Asthma_{it} \times SES_i + \delta Covariates_{it} + Fix_i + \epsilon_{it}$$

4. Results

4.1. Descriptive statistics

Table 1 presents descriptive statistics of all variables for the analytic sample of 5750 children and for subgroups of children divided by asthma diagnosis status at the preschool year. As shown in the first column, approximately one-tenth of children (11%) were diagnosed with asthma by a physician. Furthermore, 7% of children had an asthma attack since the last interview, and 3% of children were hospitalized at least one night due to asthma.

The remaining columns of Table 1 present descriptive statistics categorized by the status of asthma diagnosis. There are two interesting patterns. First, child behavioral outcomes varied by asthma diagnosis status. As expected, children who were diagnosed with asthma displayed lower scores on attention and social competence and were rated higher on the externalizing problem behaviors scale. The second interesting pattern is that household SES and demographic characteristics also varied according to asthma diagnosis. Not surprisingly, children who were diagnosed with asthma were members of the more socially and economically disadvantaged families. They were more likely to be African

Table 2

Effects of asthma on child behavioral skills, individual fixed-effects model (N = 5750).

	Attention Coefficients (S.E.)	Social competence coefficients (S.E.)	Externalizing problem behaviors Coefficients (S.E.)
Asthma	−0.145*** (0.028)	0.017 (0.029)	0.195*** (0.028)
child age	0.015*** (0.002)	0.008*** (0.002)	−0.013*** (0.002)
Number of siblings	−0.002 (0.008)	−0.035*** (0.008)	0.059*** (0.008)
Single parent	−0.779*** (0.020)	−0.034 (0.020)	0.267*** (0.020)

Note. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$. Reports of sample size were rounded to the nearest 50 because of the requirement of the restricted-use license agreement of the ECLS-B data.

American, live in a single-parent household, experience economic hardship, and have mothers who smoked at home and who were unemployed. Children with asthma were less likely to be covered by private health insurance and often lived in families that reported higher levels of parenting stress and maternal depression.

4.2. Socioeconomic disparities in the developmental consequences of asthma

The results from the fixed-effects models of the influence of asthma on child behavioral skills are shown in Tables 2 through 4. I begin with the associations between asthma and three behavioral outcomes, which are adjusted for child age, number of siblings, and family structure (Table 2). Consistent with prior biomedical research, an asthma diagnosis was associated with lower levels of attention and higher levels of externalizing problem behaviors in children. Asthma was not associated with social competence. However, this analysis does not consider socioeconomic standing as a fundamental factor that influences the developmental consequences of asthma. To address this issue, I included interactions between asthma and socioeconomic indicators. Table 3 presents the results in terms of the levels of maternal education, and Table 4 shows the results in terms of household poverty history.

As Model 1 of Table 3 shows, the diagnosis of asthma was associated with lower levels of behavioral skills for children whose mothers had no high school degree. More specifically, the diagnosis of asthma was associated with a decrease in attention rating by 0.407 standard deviations and an increase in externalizing problem behaviors by 0.478 standard deviations. Furthermore, the interaction terms were statistically significant, and the coefficients increased with maternal education. In the case of children's attention rating, the coefficient for the interactions was 0.119 for children with high school-educated mothers and 0.374 for children with mothers with some college, and it increased to 0.503 for children whose mothers had college degrees or higher. With respect to externalizing problem behaviors, similar patterns were found. The interactions were the largest for children with college-educated mothers, followed by those with some college and those with only a high school education.

Table 4 shows the effects of asthma on child behavioral outcomes in terms of household poverty history. Model 1 shows that asthma was associated with lower levels of attention and lower social competence ratings and higher externalizing problem behaviors for children who experienced long-term poverty. However, all interactions between asthma and never having been in poverty were positive and statistically significant, suggesting that the negative consequences of asthma on child behavioral outcomes were smaller or minimal for children who never experienced economic deprivation. Interestingly, asthma appeared to have larger effects on children's attention and externalizing problem

Table 1

Weighted descriptive statistics by early childhood asthma diagnosis status in the baseline year.

	Full sample (N = 5750)	By asthma diagnosis status	
		No asthma (N = 4850)	Diagnosed asthma (N = 900)
Asthma			
Asthma diagnosis	11%	na	100%
Asthma attack	7%	na	65%
Asthma hospitalization	3%	na	31%
Child behavioral skills			
Attention	0	0.09	−0.09
Externalizing problem behaviors	0	−0.06	0.11
Social competence	0	0.01	−0.03
Covariates			
Male	50%	49%	58%
Child age (in month)	52	52	52
Child race			
White	51%	52%	42%
Black	15%	13%	27%
Hispanic	26%	27%	24%
Asian	3%	3%	2%
Other	5%	5%	5%
Maternal education			
No HS	16%	16%	17%
HS	28%	28%	29%
Some college	29%	28%	33%
College or above	27%	28%	21%
Poverty history			
Long-term poverty	17%	16%	26%
Short-term poverty	13%	12%	15%
Never being in poverty	70%	72%	59%
Number of siblings	1.4	1.4	1.3
Single-parent family	29%	27%	42%
Mother unemployed	5%	5%	7%
Private health insurance	62%	63%	55%
Months no insurance	1	1	1
Parenting stress	0	−0.08	0.06
Maternal depression	0	−0.09	0.06
Positive parenting	0	0.03	0.07
Mother smoking at home	11%	10%	12%
Urban residency	83%	82%	84%
Unsafe neighborhood	6%	5%	8%

Reports of sample size were rounded to the nearest 50 because of the requirement of the restricted-use license agreement of the ECLS-B data.

Table 3
Effects of asthma on child behavioral skills by maternal education, individual fixed-effects model ($N = 5750$).

	Attention Coefficients (S.E.)				Social competence Coefficients (S.E.)				Externalizing problem behaviors Coefficients (S.E.)			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Asthma	-0.407*** (0.065)	-0.356*** (0.065)	-0.283*** (0.062)	-0.260*** (0.065)	-0.119+ (0.065)	-0.099 (0.065)	-0.033 (0.063)	-0.034 (0.066)	0.478*** (0.064)	0.439*** (0.064)	0.365*** (0.062)	0.415*** (0.066)
Private insurance		0.185** (0.021)	0.133*** (0.020)	0.123*** (0.020)		0.069** (0.021)	0.027 (0.020)	0.041* (0.020)	-0.142*** (0.021)	-0.093*** (0.020)	-0.078*** (0.020)	-0.078*** (0.020)
Months no insurance		-0.001 (0.003)	0.001 (0.002)	0.001 (0.003)		0.006* (0.003)	0.008* (0.003)	0.007* (0.003)	0.011** (0.003)	0.009** (0.003)	0.009** (0.003)	0.009** (0.003)
Parenting stress			-0.123*** (0.009)	-0.125*** (0.010)			-0.154*** (0.010)	-0.149*** (0.010)			0.131*** (0.010)	0.137*** (0.010)
Maternal depression			-0.082*** (0.010)	-0.075*** (0.010)			-0.003 (0.010)	-0.008 (0.010)			0.143*** (0.010)	0.136*** (0.010)
Positive parenting			0.212*** (0.009)	0.211*** (0.009)			0.233*** (0.009)	0.234*** (0.009)			-0.112*** (0.009)	-0.111*** (0.009)
Mother smoking at home				-0.114*** (0.030)				0.138*** (0.030)				0.181*** (0.030)
Urban residency				0.060* (0.025)				-0.039 (0.026)				-0.112*** (0.026)
Unsafe neighborhood				0.048 (0.070)				-0.045 (0.076)				-0.150 (0.079)
High school × asthma	0.119 (0.079)	0.082 (0.079)	0.022 (0.076)	-0.042 (0.080)	0.117 (0.080)	0.102 (0.080)	-0.036 (0.077)	0.029 (0.081)	-0.212** (0.079)	-0.184* (0.078)	-0.120 (0.076)	-0.164* (0.079)
Some college × asthma	0.374*** (0.080)	0.327*** (0.080)	0.186* (0.077)	0.183* (0.079)	0.229** (0.081)	0.209** (0.081)	-0.051 (0.078)	0.059 (0.080)	-0.358*** (0.079)	-0.322** (0.079)	-0.220** (0.077)	-0.264** (0.079)
College × asthma	0.503*** (0.086)	0.416*** (0.086)	0.302*** (0.083)	0.255*** (0.085)	0.119 (0.087)	0.090 (0.078)	-0.018 (0.083)	-0.006 (0.086)	-0.497*** (0.085)	-0.424*** (0.086)	-0.323*** (0.083)	-0.366*** (0.085)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$. Reports of sample size were rounded to the nearest 50 because of the requirement of the restricted-use license agreement of the ECLS-B data.

behaviors among those who experienced short-term poverty than among those who consistently lived in poverty. This result may imply that falling into poverty may be an additional source of strain for parents and families. Taken together, these results supported my hypothesis, which states that social stratification is relevant to the behavioral consequences of asthma. Asthma was associated with poor child developmental outcomes; however, children from high-SES families were less affected by asthma than their low-SES peers.

4.3. The role of healthcare resources, family process, and environmental risks

Next, I examined the role of healthcare resources, home environment, and environmental risks in explaining the SES disparities in developmental consequences of asthma. The remaining columns of Tables 3 and 4 show results from these analyses. As Model 2 of Table 3 shows, for attention and externalizing problem behaviors, the education gradients persisted after accounting for differences in private insurance coverage and months without health insurance coverage. The coefficients of asthma diagnosis and interactions between asthma and maternal education were reduced by approximately 10%. The two healthcare variables were also strong predictors of child behavioral skills. For example, private health insurance was positively related to attention and social competence and negatively correlated with externalizing problem behaviors. An additional month without health insurance coverage was associated with an increase in the externalizing problem behaviors rating of approximately 0.01 standard deviations. As demonstrated in Model 3, the coefficients were further reduced by approximately 25% with the inclusion of the home environment. Nevertheless, the education gradients persisted and remained quite large. All three home environment variables were strongly associated with behavioral outcomes in the expected directions. Adding proxies of environmental risks in Model 4 had almost no change on the education gradients despite mother smoking at home and urban residency itself were strong predictors of child behavioral skills. Taken together, although the three mechanisms together explained approximately one-third of the education differences in the influence of asthma on child attention and externalizing problem behaviors, they did not fully explain the gradients.

Next, Table 4 shows results from similar analyses when household poverty is the focus. The patterns are similar to those in Table 3. Model 2 shows that economic disparities in behavioral outcomes persisted after accounting for healthcare variables. Interestingly, healthcare resources explained a greater proportion of the economic gradients in the behavioral consequences of asthma, particularly attention, than did education gradients. The inclusion of the home environment in Model 3 further reduced the socioeconomic gaps. In particular, the gaps in attention between poor and non-poor children were substantially reduced and the interactions became insignificant. The inclusion of proxies of environmental risks in Model 4, however, did not reduce the economic disparities further. These results suggest that differences in the home environment and healthcare resources together explained most of the disparities in asthmatic children's attention ratings. However, for social competence and externalizing problem behaviors, the gradients remained strong. The three broad mechanisms together explained approximately one-third of the differences in the consequences of asthma between poor and non-poor children. Taken together, these results reveal that socioeconomic disparities in asthma's impacts on child behavioral skills cannot be completely reduced to inequalities in healthcare resources, family process, and environmental risks.

Table 4
Effects of asthma on child behavioral skills by household poverty history, individual fixed-effects model ($N = 5750$).

	Attention Coefficients (S.E.)				Social competence Coefficients (S.E.)				Externalizing problem behaviors Coefficients (S.E.)			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Asthma	–0.265*** (0.053)	–0.220*** (0.053)	–0.202*** (0.051)	–0.204*** (0.051)	–0.123* (0.054)	–0.107* (0.053)	–0.106* (0.051)	–0.109* (0.051)	0.366*** (0.053)	0.333*** (0.053)	0.304*** (0.051)	0.313*** (0.051)
Private insurance		0.189*** (0.021)	0.136*** (0.020)	0.125*** (0.020)		0.065** (0.021)	0.023 (0.020)	0.037 (0.020)		–0.141*** (0.021)	–0.091*** (0.020)	–0.077*** (0.020)
Months no insurance		–0.001 (0.003)	0.001 (0.003)	0.001 (0.003)		0.006* (0.003)	0.008* (0.003)	0.007* (0.003)		0.011*** (0.003)	0.009** (0.003)	0.009** (0.003)
Parenting stress			–0.123*** (0.009)	–0.125*** (0.010)			–0.155*** (0.010)	–0.149*** (0.010)			0.132*** (0.010)	0.138*** (0.010)
Maternal depression			–0.082*** (0.010)	–0.076*** (0.009)			–0.003 (0.010)	–0.008 (0.010)			0.142*** (0.010)	0.135*** (0.010)
Positive parenting			0.213*** (0.009)	0.213*** (0.009)			0.233*** (0.009)	0.234*** (0.009)			–0.112*** (0.009)	–0.112*** (0.009)
Mother smoking at home				–0.118*** (0.030)				0.140*** (0.030)			0.184*** (0.030)	0.184*** (0.030)
Urban residency				0.062* (0.025)				–0.039 (0.026)				–0.111*** (0.026)
Unsafe neighborhood				0.046 (0.070)				–0.041 (0.076)				–0.150 (0.078)
Short-term poverty × asthma	–0.083 (0.085)	–0.096 (0.085)	–0.056 (0.081)	–0.051 (0.082)	0.110 (0.087)	0.107 (0.087)	0.141 (0.080)	0.140 (0.083)	0.104 (0.085)	0.116 (0.085)	0.074 (0.082)	0.065 (0.082)
Never being in poverty × asthma	0.224*** (0.063)	0.160* (0.063)	0.098 (0.061)	0.095 (0.060)	0.201** (0.064)	0.180** (0.064)	0.126* (0.061)	0.136* (0.061)	–0.317*** (0.062)	–0.268*** (0.063)	–0.212*** (0.060)	–0.214*** (0.061)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

4.4. Additional analyses

Additionally, I examined the socioeconomic disparities in asthma's impacts on child behavioral skills of more severe cases (defined as being hospitalized for at least one night due to asthma). Given that more severe cases are easier to identify because the symptoms upon which a diagnosis are made are less ambiguous (King and Bearman, 2011), the focus on severe asthma provides an opportunity to check the robustness of the previous findings. If socioeconomic gradients in child behavioral consequences of asthma are observed for more severe cases, the notion that the critical role of SES in shaping the developmental consequences of asthma is better supported.

The use of hospitalization as an indicator of severity may raise the concern whether it reflects children's illness conditions or capture the resourcefulness of families. Prior research suggests that hospitalization is a reliable indicator of severity of children's asthma and reflects children's medical needs because children who were hospitalized due to asthma show no difference in clinical symptoms of severity by socioeconomic status (Boudreaux et al., 2003; McConnochie et al., 1999). Another concern is that low SES children may have a higher risk of hospitalization given the same severity. Studies using convenient samples suggest that this may be the case under a universally accessible healthcare system (Amre et al., 2002). However, in a private healthcare system such as United States, the higher rates of asthma hospitalization among low SES children often reflect greater needs and increased morbidity instead of "overutilization" (Halfon and Newacheck, 1993; McConnochie et al., 1999). Additionally, the survey question asked if the child had been hospitalized for at least one night due to asthma. This might exclude ER visits since not all ER visits resulted in at least one night of hospitalization and thus better captured asthmatic children's actual hospitalization. Hence, despite not ideal, I am confident that hospitalization is a reasonable indicator of severe asthma in this study.

Results, presented in Table 5, demonstrated that the socioeconomic gradients in behavioral consequences of asthma were observed for both mild and severe cases. It is less likely that the observed gradients are due to the misdiagnosis of children's asthma. Thus, the severe asthma analyses provide additional support for the notion that SES is a crucial social factor in shaping of developmental consequences of asthma.

Asthma may be misdiagnosed. Diseases with similar symptoms may be diagnosed as asthma or vice versa. This is particularly true in the case of children with mild symptoms, in which the diagnosis of asthma is more difficult and the criteria may be ambiguous. To address this concern, I replicated all analyses using asthma attacks as an indicator of asthma diagnosis. Again, for children with asthma attacks, the diagnosed criteria are less ambiguous and, thus, the probability of misdiagnosis is significantly reduced. Although the coefficients were somewhat different, the patterns were unchanged.

An additional concern was that the poor behavioral outcomes of low-SES children may be due to other changes in the social environment that were correlated with asthma diagnoses and behavioral outcomes. Thus, I performed additional analyses that controlled for residential instability to reduce the likelihood that unmeasured confounders influenced the results. The results were similar, supporting the original conclusion.

Finally, I tested whether the results were sensitive to the coding schemes of SES. First, I recoded maternal education solely based on the highest degree completed by the preschool year of the survey. Second, I recoded the household poverty history based on the poverty status in the preschool and kindergarten waves rather than all four available waves. The results were unchanged. Thus, the

findings were not affected by the coding schemes of the small proportions of mothers whose education changed during the surveys and the method of categorizing household poverty history.

5. Discussion and conclusion

The epidemic of childhood asthma has caused substantial concern regarding its impacts on child development. However, the extant research does not fully consider the role of the socioeconomic inequality in determining the developmental consequences of this disease, and there has been a notable absence of attention to the inequalities of the developmental consequences of asthma in the literature. This is an oversight because all children, including asthmatic children, live in a stratified world. Their positions in the stratification system have the potential to shape the consequences of their illness. Prior research has demonstrated a strong link between socioeconomic standing and child behavioral and psychological wellbeing (McLeod and Nonnemaker, 2000; McLeod and Owens, 2004; McLeod and Shanahan, 1996). The current study combines theoretical and empirical research on SES and health to highlight how socioeconomic position intersects with individual health disadvantages in shaping children's developmental trajectories.

I found strong gradients in asthma's impacts on child behavioral skills by maternal education and household poverty history. Specifically, asthma was negatively associated with attention and social competence and positively associated with externalizing problem behaviors for children with low-education mothers and who lived in poor households. However, the adverse consequences of asthma on child behavioral outcomes decreased with increases in maternal education and household economic status. Furthermore, the socioeconomic gradients persisted with the inclusion of healthcare resources, family process, and environmental risks as explanatory factors. This finding suggests that the source of inequalities in the impacts of asthma on child outcomes cannot be completely reduced to unequal distribution of healthcare resources, differences in family process, and inequalities in exposure to environment risks. In sum, these results not only demonstrate that the developmental consequences of asthma are modified by socioeconomic background, but also provide support for the fundamental cause perspective (Link and Phelan, 1995; Phelan et al., 2010).

Notably, although healthcare resources and family process are not the principal factors that contribute to inequalities in the developmental outcomes of asthma, they are powerful factors. Together, they explained approximately one-third of the socioeconomic gradients in the behavioral consequences of asthma. However, healthcare resources and family process did not display equal explanatory power. The analysis shows that family process appears to be more important than healthcare resources in explaining disparities in the behavioral consequences of asthma. Prior sociological works suggest that family environment plays more critical roles in determining children's life chances than material resources (Augustine and Crosnoe, 2010; Mayer, 1997). The findings of the current study may be considered as additional support for this perspective, demonstrating the role of family process in explaining the socioeconomic disparities in the developmental consequences of asthma.

There are several limitations of the present study. First, the information on childhood asthma in ECLS-B was not based on the direct assessment of children's asthma-related symptoms; rather, it relied on maternal reports of asthma diagnosis. Thus, I cannot rule out the possibility of misdiagnosis. Conventional wisdom suggests that children who are racial minorities and those from socially and economically disadvantaged backgrounds may be more likely to be under-diagnosed. Although I cannot verify this hypothesis using

ECLS-B data, a recent study finds evidence to the contrary (Akinbami et al., 2005). Furthermore, as previously described, I performed additional analyses using severe asthma as an indicator because the diagnosis criteria for severe cases are less ambiguous. As the probability of misdiagnosis is significantly reduced for more severe asthma cases, these additional analyses serve as useful robustness checks. Results from these analyses suggest that my findings are not considerably altered by the measurement error of asthma diagnosis. Second, the ECLS-B data did not provide numerical household incomes or income-to-poverty ratios. Therefore, I was unable to analyze the economic gradients in behavioral outcomes in greater detail. Third, measures of family process may have measurement errors and only capture certain dimensions of family process. Family process might explain greater proportion of the socioeconomic disparities in developmental consequences of asthma if additional measures were available. As such, the current results might provide conservative estimates of the power of family process in explaining the differential developmental consequences of asthma. Fourth, measures of environmental risks may not perfectly capture all indoor and outdoor exposures that influence developmental consequences of asthma. This may be one reason why environmental risks explained only a very small proportion of SES disparities in this study. If better indicators were available, environment risks might play a more important role in explaining the associations. However, given that these measures were significantly associated with child behavioral skills, they remained meaningful proxies of environment risks. Fifth, by considering three proposed mechanisms as mediating processes, the statistical analysis assumed that child behavioral skills did not affect healthcare resources, family process, and exposure to environmental risks and no measurement error of mediators. While the first assumption was more likely to be met, the second assumption might be not. The presence of measurement errors might make this study underestimate the mediating effects of the proposed mechanisms. Finally, this study limited the scope of inquiry to asthma to capitalize on analytical clarity. The perspective proposed in this study, nonetheless, is more general in nature. It would be interesting for future studies to apply and extend these ideas to other child health problems or other dimensions of developmental outcomes.

With these limitations, Findings suggest that the basic constituent properties of fundamental cause perspective may be applicable to the understanding of outcomes that are not “health” outcomes in a strict sense. The perspective emphasizes the power of socioeconomic status in generating an enduring inverse SES–health relationship. As social stratification system determines the distribution of resources and information, a persistent association between socioeconomic status and health is created and maintained despite the advances of medical technology and substantial investments in public health (Link and Phelan, 1995). The core concept of the perspective—“fundamental causality”—points to the need to contextualize risk factors and specific mechanisms into an encompassing construct such as the social stratification process (Freese and Lutfey, 2011). In this way, the concept is not only useful for understanding the enduring relationship between SES and health, but also stimulates consideration of the robust relationships between basic social conditions and life chances, which has great potential to extend to fields outside medical sociology (Lutfey and Freese, 2005). As such, this study may be viewed as a first attempt to apply and extend the notion of fundamental causality to outcomes that have long been the purview of the family studies and human development. Findings from this study may also suggest that SES not only is a “meta-mechanism” of health as sociologists proposed (Lutfey and Freese, 2005) but also may be a meta-mechanism for social consequences of illness because SES can potentially create an abstract mechanism that explains the

Table 5Effects of asthma and asthma hospitalization on child behavioral skills by maternal education and by poverty history ($N = 5750$).

	Attention Coefficients (S.E.)	Social competence Coefficients (S.E.)	Externalizing problem behaviors Coefficients (S.E.)
Panel A: maternal education			
Asthma diagnosis	−0.231 (0.074)**	0.017 (0.075)	0.404 (0.075)***
Asthma hospitalization	−0.360 (0.137)**	−0.206 (0.138)	0.451 (0.135)**
High school × diagnosis	−0.113 (0.091)	−0.029 (0.093)	−0.182 (0.091)*
Some college × diagnosis	0.178 (0.089)	−0.024 (0.091)	−0.287 (0.090)**
College × diagnosis	0.199 (0.097)	−0.060 (0.098)	−0.283 (0.097)**
High school × hospitalization	0.168 (0.162)	0.220 (0.164)	−0.128 (0.161)
Some college × hospitalization	0.311 (0.163)+	0.327 (0.164)*	−0.300 (0.162)+
College × hospitalization	0.429 (0.171)*	0.177 (0.173)	−0.602 (0.170)***
Panel B: poverty history			
Asthma diagnosis	−0.230 (0.059)***	−0.085 (0.060)	0.283 (0.059)***
Asthma hospitalization	−0.130 (0.096)	−0.173 (0.097)+	0.325 (0.096)**
Short-term poverty × diagnosis	0.016 (0.096)	0.161 (0.097)	0.002 (0.096)
Never being in poverty × diagnosis	0.112 (0.070)	0.083 (0.070)	−0.219 (0.070)**
Short-term poverty × hospitalization	−0.223 (0.154)	0.094 (0.158)	0.221 (0.154)
Never being in poverty × hospitalization	0.051 (0.117)	0.292 (0.117)*	−0.303 (0.116)*

Note. + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Reports of sample size were rounded to the nearest 50 because of the requirement of the restricted-use license agreement of the ECLS-B data. All statistical analyses were based on the individual fixed-effects model controlling for all aforementioned variables. Coefficients of these variables were not reported for brevity.

generation of multiple mechanisms that produce social disparities in developmental consequences of illness.

While these studies focused on three specific mechanisms due to its importance in the literature and policy implications, there may be other potential mechanisms that channel SES and consequences of illness. For example, SES may influence social network as well as the quality of childcare and school which can both shape developmental consequences of illness in children. Future studies that examine the role of these mechanisms may offer additional evidence for the argument proposed in this study.

Second, prior studies on differential consequences of illness focus more on outcomes in adolescence and adulthood (Carlsen et al., 2008; Lindholm et al., 2002). The current study adds to the literature by highlighting not only the differential development consequences of asthma, but also how SES modifies consequences of illness at the early stages. From a life course perspective, early-life skills play a crucial role in setting subsequent developmental and learning trajectories which, in turn, affect education attainment and labor market success in adulthood (Caspi et al., 1998). As such, results from this study complement with prior research on differential consequences of illness in education and employment outcomes. The focus of behavioral consequences of illness in the present study also illuminates that social stratification may shape consequences of illness in every aspect of social outcomes. Future studies of the differential social consequences of illness may benefit from adapting a life course perspective and taking a broader conceptualization of social outcomes.

Finally, the results offer a novel examination of the developmental consequences of childhood diseases, complementing the large body of biological and psychological evidence regarding the developmental outcomes of asthmatic children. The findings imply that biology is not destiny. Illness influences the developmental trajectories of individuals through a complex intersection of biological and social processes. The developmental consequences of childhood asthma are not universal and solely determined by biological mechanisms. The contextualization of the risk factors, social or biological, provides a more comprehensive understanding of the developmental inequality. This point is consistent with the ecological perspective on human development (Bronfenbrenner, 1979; Shonkoff and Phillips, 2000) as well as the Diderichsen model in social epidemiology (Carlsen et al., 2008; Lindholm et al., 2002).

With respect to health policy, results from this study should serve as an alert to government agencies to direct their investments toward asthmatic children in low-SES families. Extant research and practices primarily emphasize locating modifiable risk factors that link asthma and child outcomes. Intervention programs that aim to eliminate such mechanisms are then designed. Although such intervention research may improve the overall developmental outcomes of asthmatic children, there is very little policy attention to the developmental inequalities of chronically-ill children. The improvement in the overall wellbeing and reduction in the developmental inequalities of asthmatic children are both important goals. The findings indicate that social policies that aim to reduce socioeconomic inequalities may be as relevant to the promotion of the wellbeing of asthmatic children as public health interventions.

To conclude, the theoretical and empirical approach adopted in this article reflects that to understand the consequences of diseases, it is not sufficient to focus on evaluations of clinical studies and solely rely on biomedical knowledge – an approach that motivates many existing studies. Uncovering the social structural conditions through which health disadvantages in early childhood compound over time should be a central goal in the pursuit of a complete understanding of the maintenance and reproduction of inequality. Such examinations can also constitute the bases for better policy solutions.

Ethics approval/statement

This study is a secondary data analysis and ethics statement is not required.

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