Early Physical Health Problems as Developmental Liabilities for School Readiness: Associations with Early Learning Contexts and Family Socioeconomic Status

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EARLY PHYSICAL HEALTH PROBLEMS AS DEVELOPMENTAL LIABILITIES FOR SCHOOL READINESS: ASSOCIATIONS WITH EARLY LEARNING CONTEXTS AND FAMILY SOCIOECONOMIC STATUS

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ABSTRACT

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Emerging research suggests that children's physical health may account for some of the variability in developmental competencies at school entry, which are the cognitive, learning, and behavioral skills necessary for long-term academic achievement. Most studies on children's health find that neonatal risks, like low birth weight and premature birth, impair children's early functioning, but little is known about other domains of children's health, like global health or acute and chronic conditions, which may be associated with functioning at school entry. Moreover, it is unclear what role physical health may play in children's access to and engagement in home and early childhood education center-based learning contexts, which may function as pathways linking early health disparities with later development. This dissertation tested direct associations between a range of childhood health problems and school readiness skills at kindergarten entry, as well as indirect and interacted associations with early learning contexts. Given the well-established socioeconomic gradient in both health and development, analyses also explored whether associations linking health and development were conditional on family socioeconomic status.

Data were drawn from the nationally representative Early Childhood Longitudinal Study (Birth Cohort; N = 5,900), which follows a cohort of children born in 2001 from infancy through kindergarten entry. Linear regressions and path analyses revealed that

four of five health conditions were associated with lower school readiness skills, most consistently in the domains of cognitive and learning skills. Neonatal risks, poor health, and hospitalization functioned directly to predict lower cognitive and learning skills, where as asthma diagnosis predicted heightened learning skills. Only poor health functioned indirectly through more restricted home learning activities. Children's time in ECE functioned in a compensatory role to attenuate associations between hospitalization and lower school readiness skills. Across all models, there was no evidence that measured associations varied across the family socioeconomic spectrum. Findings highlight the importance of interdisciplinary research on child well-being and draw attention to potential avenues for prevention and intervention.

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CHAPTER 1: PROBLEM STATEMENT

Mounting research suggests that early physical health status may forecast children's long- term developmental outcomes throughout childhood and into adulthood. Past research has primarily focused on children's neonatal risks, such as low birth weight and premature birth, as proxies for overall health status. In general, these studies reveal that children who experience early health insults are more likely to suffer inadequate educational attainment, lower social status, and limited economic productivity across the lifespan than their healthier counterparts (Case, Fertig & Paxson, 2005; Haas & Fosse, 2008; Knudsen, Heckman, Cameron & Shonkoff, 2006; Lê, Roux & Morgenstern, 2013; Ziol-Guest, Duncan, Kalil & Boyce, 2012). Some research has identified evidence of links between neonatal risks and more immediate repercussion for impairments in children's development, namely in the domain of cognitive functioning, from infancy through early childhood (Delobel-Ayoub et al., 2006; Mikkola et al., 2005; Morse, Zheng, Tang, & Roth, 2009). This body of literature attributes deficits in cognitive functioning to children's reduced brain size, immature neurophysiology, and related medical conditions (Reichman, 2005). Given that neonatal risks may predispose children to other health problems in addition to impaired cognition (Stein, Siegel, & Bauman, 2006), a major limitation of the current literature is the inadequate empirical attention to a broader range of early physical health indicators that may interfere with children's learning opportunities during a crucial developmental window and ultimately undermine early development.

Indeed, a recent outpouring of empirical research has strengthened the argument that the skills children bring to their first formal schooling experiences, namely cognitive

skills (i.e., math and reading), self-regulatory skills (i.e., attention, motivation to learn), and socio-emotional skills (i.e., prosocial behavior, lack of emotional or behavior problems) are especially formative and have long-lasting implications (Snow, 2006; Zill & West, 1995). On the whole, children who enter school with superior skills adjust more easily to kindergarten and show better academic and behavioral functioning over time (Duncan et al., 2007; Duncan & Magnuson, 2011; Lo Paro & Pianta, 2000; McClelland, Acock & Morrison, 2006). School readiness skills are not only integral to children's success in kindergarten and throughout elementary school, but studies also suggest that these competencies are essential for long-term population well-being and economic productivity (Knudsen et al., 2006).

Considering the wide-reaching implications of children's school readiness skills, it is alarming that research has inadequately explored how children's physical health indicators may explain variability in early competencies. Children make notable contributions to their own development, yet most studies have overlooked the contribution of children's health to their school readiness skills. There is emerging evidence linking a variety of individual health indicators to young children's cognitive functioning (Halterman et al., 2001; Janus & Duku, 2007) but less frequently to social or emotional functioning. Unfortunately, these studies have numerous limitations and are constrained in their generalizability by the use of small, epidemiological samples drawn from restricted economic strata, racial/ethnic subgroups, or urban centers (Halterman et al., 2001; Roberts et al., 2000; Weil et al., 1999). Additionally, with few exceptions (e.g., Crosnoe, 2006; Spernak, Schottenbauer, Ramey, & Ramey, 2006), prior studies have

often taken a piecemeal approach, lacking a comprehensive view that accounts for the multi-faceted nature of health across the developmental span of early childhood.

A third limitation of the extant literature is the restricted evidence base on potential mechanisms that may explain associations between early health problems and school readiness skills. The transactional-ecological theory of development suggests that physical health may function in two potentially overlapping ways. First, parents may either provide or inhibit development-promoting learning opportunities on the basis of the child's health; for example, some children are perceived to be too ill to participate in learning activities in the home environment or in early childhood education contexts. Second, access to early learning contexts may help children in poor health to compensate for early impairments or further promote the development of healthy children (Bronfenbrenner & Morris, 1998; Sameroff & Chandler, 1975). In short, there has been limited attention to the role that early learning contexts play in the association between children's physical health and the development of school readiness skills.

In addition to examining overlapping disparities in children's health and development, this study also attends to essential socioeconomic disparities at the intersection of health and development. Evidence of a socioeconomic gradient in the domains of health and development may be the most robust findings across the social science literature. Generally, children raised in families with less income and lower educated parents experience a greater number and severity of health conditions (Braveman & Barclay, 2009; Fiscella, Franks, Gold, & Clancy, 2000), due to a combination of factors such as environmental exposures and less consistent access to high quality care (Newacheck, Hughes, & Stoddard, 1996). Low-SES children also show

lower developmental competencies at school entry (Brooks-Gunn, Rouse, & McLanahan, 2007), which emerging research has attributed to fewer enriching early experiences in the home and less access to center-based early education experiences (Bradley, 2002; Capizzano & Adams, 2004), though experimental and correlational research finds these experiences to have the strongest benefits for children who have the most to gain (Gormley & Gayer, 2005; Votruba-Drzal, Coley, Koury, & Miller, 2013). Hence, it is unknown whether links between health and development function similarly across a population of young U.S. children or differ across the spectrum of family socioeconomic resources in the domains of household income and maternal education.

To address these limitations, this dissertation has four primary aims. The first aim was to examine direct associations between five indicators of physical health assessed from infancy through age 4 and children's cognitive and socio-emotional competencies at age 5, when most were entering kindergarten. The second aim was to explore whether access to home- and ECE-based early learning opportunities in the year before school entry functioned as indirect pathways through which children's early physical health problems were associated with their readiness for school. The third aim was to test whether children's participation in early learning contexts attenuated hypothesized links between health problems and lower school readiness skills or exacerbated the school readiness gap between healthy and unhealthy children. The final aim was to investigate whether these proposed linkages differed across levels of family resources, which may protect advantaged children from the hypothesized negative associations concerning health problems and impaired school readiness skills, and as a result, may further exacerbate school readiness disparities between advantaged and disadvantaged children.

CHAPTER 2: LITERATURE REVIEW

Theoretical Motivation

Developmental theory argues that the processes by which individuals affect their environments and their environments affect them are complex and multi-faceted. This notion reflects a transactional-ecological model (National Research Council, 2000), which suggests that determinants of health and development are a function of bidirectional relations between individuals' selection into certain contexts and their interactions with those contexts. An integral component of this model is an individual's own characteristics, or what Bronfenbrenner and Morris (1998) first called "person" characteristics, which are responsible for interacting with the environment to propel proximal processes and hence, development.

A major tenet of the transactional-ecological framework argues that development occurs through bidirectional and reciprocal interactions between the child and his/her caregivers (Sameroff & Chandler, 1975). Hence, parents' interactions with and investments in their child are in part determined by the child's characteristics and behaviors, a process commonly described in the literature as *child evocative effects* (Rutter, 2007). It is possible that children's early physical health might be one of the key child characteristics that parents recognize and assess when they decide what kinds of experiences to make available to their children, meaning that health may function as an evocative force. Indeed, extant literature finds that parents make decisions about how to interact with and care for children in response to children's physical health conditions (Anthony, Gil, & Schanberg, 2003; Barrera, Rosenbaum, & Cunningham, 1986; Crnic &

Greenberg, 1987; Fiese, 1997; Hauser et al., 1986; Kai, 1996; Schumacher, Beilder, Beeber, & Gambino, 2006).

A second tenet of the transactional-ecological framework is that individual characteristics of children, the "person" characteristics as described by Bronfenbrenner and Morris (1998), interact with the environment to affect proximal processes that foster or inhibit development. Other work (e.g., Wachs, 2000) has referred to this concept as the "fit" between the traits that children bring to a particular context and the opportunities conferred by that context. Poor physical health, for example, may interact with children's environments in a variety of ways to influence development that depends on the fit between the child's well-being and the learning opportunities in ECE or home contexts. To the extent that sick children are constrained in their engagement in peer socialization and learning opportunities across infancy and toddlerhood, then sick children may show greater benefits from exposure to early learning opportunities in the year before school entry than children in good health. Conversely, learning opportunities in these contexts may be most beneficial for children in good health who can most optimally engage in structured and supportive development-promoting and socialization opportunities, consequently promoting development in comparison to children experiencing health problems. Bradley and colleagues (Bradley, McKelvey & Whiteside-Mansell, 2011) identify these types of processes as either *compensatory* or *potentiating*, such that engagement in early learning contexts either prevents health-related impairments in development or leverages children's good health for promoting optimal development.

Furthermore, a cadre of researchers in pediatrics and child development has recently called for more work that addresses the overlap between children's biological

characteristics and psychological development (Blair, 2002; Bronfenbrenner & Morris, 1998; Shonkoff, 2010; Shonkoff & Garner, 2012). Emerging research at this intersection suggests that children's health, development, and general well-being are a function of complex interactions between an individual's genes, physiological functioning, and experiences in the environment (Meaney, 2010). Studies show that adversity experienced in childhood can disrupt natural neurobiological, developmental, and physiological processes that result in a higher risk for psychological impairments and a range of poor health outcomes. In short, these studies provide evidence for the intricate links between physical health and development and the need for greater attention to delineating directionality and processes underlying such relationships.

The Development of School Readiness Skills

The idea of school readiness as a comprehensive and multi-dimensional standard of developmental competence in early childhood first gained prominence in 1989 when then President Bush proposed that "all children … will start school ready to learn" as a major goal for education in the United States (Lewit & Baker, 1995, p. 128). Since then, there has been much debate about what constitutes school readiness, how to measure it, and how to promote it, but there is emerging consensus among researchers and early educators that school readiness comprises the cognitive, socio-emotional, and regulatory or learning skills that children need for adjustment to kindergarten and for long-term academic success (Snow, 2006). Along these lines, children's abilities to demonstrate nascent language, reading and math skills, to constrain inappropriate behaviors, to attend to and focus on tasks, and to interact prosocially with their peers are each important elements of their overall developmental competence at school entry.

Children show substantial variability in school readiness skills when they enter kindergarten. In fact, a national sample of teachers reported that only half of children successfully transitioned to kindergarten (Rimm-Kaufman, Pianta & Cox, 2000). This is an alarming statistic, considering that school readiness skills are crucial for classroom adjustment, with more competent children adapting more easily to the transition to school (Lewit & Baker, 1995). Other studies identify the longer-term repercussions of children's school readiness skills for functioning in middle childhood, indicating that deficits in abilities to heed instruction, pay attention, and behave hinder academic achievement throughout elementary school (Blair, 2002; McClelland et al., 2006; Raver, Garner & Smith-Donald, 2007; Welsh, Nix, Blair, Bierman & Nelson, 2010). Moreover, studies show that children's pre-academic skills, meaning their early language, reading, and math knowledge, set the foundation for long-term academic success, with these skills showing the most predictive links with children's later academic achievement throughout elementary school (Duncan et al., 2007; Lo Paro & Pianta, 2000).

In addition to one line of research delineating the long-term correlates of school readiness skills, a second line of research focuses on variability in the development of children's school readiness skills across their home, family, and ECE contexts (Brooks-Gunn & Markman, 2005; Chazan-Cohen et al., 2009; Coley, Votruba-Drzal, Miller, & Koury, 2013; Duncan & Magnuson, 2005; Farver, Xu, Eppe, & Lonigan, 2006; Mesman et al., 2009; Zhai, Brooks-Gunn & Waldfogel, 2011). Unfortunately, studies have largely overlooked the possibility that children's individual characteristics, specifically their physical health, may be a crucial piece of the puzzle involved in understanding the emergence of school readiness skills.

Children's Physical Health and Links to Development

A substantial body of literature linking children's early physical health to their development has emerged from the field of economics, where researchers have been interested in identifying empirical support for the fetal origins hypothesis. This theory argues that long-term mental and physical health, as well as other indicators of well-being, can be attributed to individuals' earliest experiences in utero (Barker, 1995; Conti & Heckman, 2013). In pursuit of this aim, economists have focused on the effects of children's neonatal risks, namely low birth weight, and have employed a range of rigorous methodologies such as quasi-experimental designs and sibling and twin fixed effects regression analyses. These studies seek to identify long-term impacts of low birth weight, as a proxy for child health, on individuals' educational attainment, cognitive development, and economic productivity (Black, Deveraux, & Salvanes, 2005; Case & Paxson, 2010; Currie & Hyson, 1999). Of course, the focus on birth weight as a proxy for health obscures the potential developmental implications of other health conditions that children experience early in life (e.g., Currie, Stabile, Manivong, & Roos, 2009). Furthermore, these studies have focused almost exclusively on outcomes in late adolescence and adulthood; they pay little attention to the potential impact of early health on the influential developmental epoch of early childhood when children are establishing crucial neural connections and acquiring the skills needed for success in school (Blair, 2002). In short, this body of literature has not carefully attended to either the multidimensional nature of physical health or the role of physical health during an important window in children's developmental trajectories.

Despite the focus on birth weight as a proxy for child health in the economic literature, the past decade has seen a shift in the understanding of children's physical health as more dynamic, holistic, and ubiquitous to both general well-being and specific arenas of functioning. This shift was delineated in a report from the National Research Council/Institute of Medicine (NRC/IOM, 2004), which argued that child health should be defined as "the extent to which children or groups of children are able or enabled to a) develop and realize their potential, b) satisfy their needs, and c) develop the capacities to allow them to interact successfully with the biological, physical and social environments" (pg. 33). By re-conceptualizing children's health to meet this definition, the NRC/IOM echoes developmental theory in arguing that children's physical health status may be associated with their access to early development-promoting and learning opportunities, as well as their ability to engage in or benefit from such opportunities.

Considering that physical health may play a role in children's access to and engagement in opportunities that promote the development of early pre-academic, learning, and behavioral skills, it is essential to attend more carefully to associations between children's physical health and their developmental competencies at school entry. A recent review paper by a leading scholar in this area explored whether health disparities explained the race/ethnic gap in school readiness skills and found that a range of common mental and physical health conditions could explain up to a quarter of this gap (Currie, 2005). Other studies argue that children's physical well-being is vital at school entry, with 75% of kindergarten teachers reporting that good physical health, in addition to being well-rested and nourished, are fundamental to children's readiness to learn in a formal school setting (Lewit & Baker, 1995).

Many young children experience a range of physical health problems that may interfere with their opportunities to learn in formal settings, realize their potential, satisfy their needs, and interact with their environments. Such health conditions are commonly characterized in the pediatric literature as neonatal risks, acute and chronic health problems, or global health status, with national statistics indicating the presence of disparities across these domains of health (Wise, 2004). In 2010, 8% of children were born with low birth weight and 12% were born prior to 37 weeks gestation (Department of Health and Human Services Health Resources and Services Administration [DHHS HRSA], 2013; March of Dimes, 2010). Rates of acute health problems, defined as an illness, infection, or disease that restricts a child's activities and necessitates medical attention for less than three months, have dropped in recent years among school aged children but have remained stable among very young children (Wise, 2004). Among children under 4, more than 8% have been diagnosed with asthma (Center for Disease Control and Prevention [CDC], 2013), and asthma-related incidents and respiratory infections explain over 38% of hospital discharges in young children. As for global assessments of physical health, 13% of children under the age of 5 in 2007 were reported to be in suboptimal health (DHHS HRSA, 2009). These statistics indicate that the breadth of potential health risks that children may face is expansive, and health problems experienced early in life are quite common.

In addition to the physical toll of early health problems, such problems may also have implications for children's emerging developmental competencies. Studies have extensively documented the associations between children's neonatal risks like premature birth and low birth weight, and other domains of development in the first five years of

life (Aylward, 2005; Morse et al., 2009). Specifically, these risks are associated with a range of cognitive deficits and school outcomes including grade retention and special education placement in kindergarten and early elementary school (Chyi, Lee, Hintz, Gould, & Sutcliffe, 2008; Mikkola et al., 2005; Morse et al., 2009; Reichman, 2005), as well as increased behavior problems and impairments in effortful control skills (Delobel-Ayoub et al., 2006; Poehlman et al., 2010; Reichman, 2005). These studies largely attribute deficits in children's early developmental competencies to biological impairments and physical and learning disabilities among children who experienced neonatal complications. Although links between neonatal health risks and children's development at school entry and across elementary school have been well established (Roberts et al., 2011), much less research attends to a broad range of health problems that children face in the first 5 years of life.

Nevertheless, a small body of literature examines the repercussions of specific health conditions for children's development. Studies have shown that children with asthma required more assistance learning in preschool, performed worse on measures of school readiness skills in kindergarten, showed lower academic achievement in 1st grade, and missed more school days across elementary school (Currie, 2005; Fowler, Davenport, & Garg, 1992; Halterman et al., 2001; Liberty, Pattemore, Reid & Tarren-Sweeney, 2010). Among school-aged children with asthma, illness severity was associated with higher levels of emotional and behavior problems (MacLean, Perrin, Gortmaker & Pierre, 1992; Wamboldt, Fritz, Mansell, McQuaid, & Klein, 1998; Weil et al., 1999), but few other studies have attempted to assess the implications of the severity of conditions like asthma or respiratory infections for children's skill development. Similarly, children's

experiences of respiratory infections and recurrent ear infections predicted lower functioning on a comprehensive kindergarten assessment of development and on tests of kindergarten math skills (Patrianakos-Hoobler, Msall, Marks, Huo & Schreiber, 2009; Roberts et al., 2000). In short, an emerging body of literature on specific health conditions has explored links with outcomes such as academic achievement across elementary and middle school (e.g., Crosnoe, 2006; Currie et al., 2008), but generally have not attended to the developmental foundation, meaning school readiness skills, on which these later outcomes are established.

Somewhat less research explores associations between reports of children's global health and early development. A Canadian population-based study found that children's suboptimal health predicts lower school readiness skills on a comprehensive teacher-report assessment of children's developmental competencies in the domains of motor, cognitive, socio-emotional, language, and communication skills (Janus & Duku, 2007). Similarly, Crosnoe (2006) showed that children's suboptimal health predicted lower math skills between kindergarten and 1st grade even after controlling for initial math skills, suggesting that physical health status may have a potent influence on children's developmental competencies in the early years of formal schooling. Among school-aged children and early adolescents, worse global health predicted lower cognitive skills, more missed school, lower educational attainment, and increased psychological maladjustment (DHHS HRSA, 2009; Jackson, 2009; Joe, Joe & Rowley, 2009; Lê et al., 2013; Spernak et al., 2006; Stein & Jessop, 1984). Evidently, suboptimal global health may have important implications for the development of children's cognitive and behavioral skills.

In short, empirical research has made some headway in demonstrating links between children's physical health problems and their developmental competencies, particularly academic skills, but there remain important unanswered questions. Among the studies on young children's health, most research has focused on the implications of neonatal risks with limited attention to the range of health problems children may face such as asthma, acute conditions, or suboptimal global health or the severity of health problems, reflected by hospitalizations or visits to the emergency room. Furthermore, many studies have examined children's health and academic achievement in elementary school, but fewer focus on the essential years of early childhood, a developmental period of notable growth and skill development that sets the stage for future learning and development. Finally, with the exception of research on missed days of school among elementary school students (Joe et al., 2009), no research attends to the potential underlying pathways through which children's early physical health problems may inhibit their pre-academic, self-regulatory, and behavioral functioning at school entry.

Contributions of Early Learning Contexts to Readiness for School

Of course, the role of children's developmental contexts cannot be overlooked in understanding associations between children's physical health and their emerging developmental competencies at school entry. One of the primary developmental contexts that may play an important role is the early childhood education (ECE) context, which affords children valuable opportunities to engage in learning activities, socialize with peers, and become familiar with classroom-based settings (National Research Council, 2000). Studies find that participation in formal center-based ECE programs, in comparison to informal home-based care or parent care, has been shown to improve

children's pre-academic school readiness skills across rigorous quasi-experimental studies (Gormley & Gayer, 2005; Zhai et al., 2011) and in large-scale and population-based samples (Magnuson, Meyers, Ruhm & Waldfogel, 2004; NICHD ECCRN & Duncan, 2003). In general, studies show that center-based ECE experiences are most advantageous for developing the cognitive skills of children who have the most to gain, such as children from low-income families (Gormley & Gayer, 2005; Votruba-Drzal et al., 2013; Watamura, Phillips, Morrissey, McCartney & Bub, 2010; Winsler et al., 2008). Research on the implications of center ECE for children's behavioral functioning is mixed. Numerous correlational studies show that children who attend center-based ECE exhibit higher levels of externalizing behavior problems and lower attention skills than peers in parent care (Belsky et al., 2007; Coley et al., 2013; Loeb, Bridges, Bassok, Fuller & Rumberger, 2007), but these patterns have not been replicated in other correlational and quasi-experimental studies (Gormley & Gayer, 2005; Loeb, Fuller, Kagan, & Carrol, 2004; Zhai et al., 2011). Although associations with children's behavioral skills are mixed, the evidence suggests that ECE participation supports the growth of cognitive skills necessary for success in school, and restricted access to center-based early learning experiences may impair children's development in this domain.

A second context that is central to children's early development and school readiness is the quality of the home learning environment, which research has broadly identified as an important predictor of children's cognitive and socio-emotional functioning. High quality home learning environments are characterized by the extent of cognitively stimulating objects, materials, and enriching experiences that parents present to children either within the confines of the home, such as the number of books the

family owns or time spent reading with the children, or through parent-led enriching activities beyond the home like visits to the library or museum (Bradley, 2002; Bradley, Corwyn, McAdoo, & Garcia Coll, 2001). These home learning activities and experiences provide occasions for parents to enhance the child's knowledge of pre-academic concepts like numbers and letters and to model appropriate social behaviors (Bradley, 2002). Studies have shown that the breadth of these types of early learning opportunities are instrumental to children's functioning, with numerous correlational studies identifying associations between the quality of the home learning environment in infancy, toddlerhood, and during preschool, and children's heightened pre-academic skills in the domains of math, reading, and learning when children were age 5 and entering school (Chazan-Cohen et al., 2009; Melhuish, Phan, Sylva, Siraj-Blatchford, & Taggart, 2008; Yeung, Linver, Brooks-Gunn, 2002). Less research has focused on relations between the home learning context and preschool children's prosocial and behavioral functioning, but one study identified a positive association between the home learning environment and social skills, assessed by a composite of learning skills, prosocial behaviors, and behavior problems (Foster, Lambert, Abbott-Shim, McCarty, & Franze, 2005). Taken together, ECE and the home learning environment comprise the most critical early learning contexts in the year before children enter school.

The Role of Children's Health in the Transactional-Ecological Model

Returning again to the transactional theoretical framework (Sameroff & Chandler, 1975), one pathway through which health and development may be linked is by health problems restricting children's opportunities for early learning. Given that parents interact with and care for their child in ways that are responsive to the child's health

status (Barrera et al., 1986; Crinic & Greenberg, 1987; Fiese, 1997; Schumacher et al., 2006), poor health may limit children's access to early childhood education settings and home-based early learning activities that promote school readiness skills. Parents' fears about the child's health deteriorating, the potential for other children to become sick, or ECE providers' limited ability to care for sick children may impede access to ECE among children in poor health, thereby excluding them from fundamental development-promoting activities in ECE contexts. Parents of sick children may also provide fewer cognitively-stimulating activities in the home, given the prioritization of the child's physical well-being over early learning, or parents' beliefs that a sick child should not risk infecting other children by going to the library or pursuing activities that might involve interacting with peers. Alternatively, parents may attempt to compensate with learning activities in the home for children whose illnesses result in restricted opportunities to engage with other children outside of the home, as in ECE settings.

Despite the well-established value of ECE participation for early childhood development, no empirical research to date has clearly delineated the role of children's health in their access to ECE. Research on parental preferences has found that parents view informal home-based ECE as more accommodating, with home childcare providers more likely to care for children when they are sick (Li-Grining & Coley, 2006). Furthermore, parents who are concerned about their child being able to attend ECE when the child is sick are more likely to select informal care over center-based ECE (Coley, Votruba-Drzal, Collins, & Miller, 2014; Early & Burchinal, 2002). These findings suggest that parents of children with health problems might be inclined to place the child in an informal care setting that is more flexible, possibly forfeiting important

development-promoting and learning opportunities available to the child in center-based ECE. In short, poor physical health may be indirectly associated with school readiness skills through children's restricted access to ECE.

In regards to predictors of the home learning environment, a notable body of literature drawn from economics argues that parents may differentially invest in children on the basis of the child's health endowments, with parents theoretically more likely to invest in healthy children who have the greatest chance of economic success (Becker & Tomes, 1976). Studies informed by this theory generally focus on birth weight as a proxy for health and illuminate associations with investments like breastfeeding duration, supportive parenting behaviors, time spent on educational activities, or frequency of doctors' visits (Datar, Kilburn, & Loughran, 2010; Hsin, 2012; Lynch & Brooks, 2013), with results yielding mixed or null effects of birth weight after controlling for family effects. Only one study examined a range of physical health problems and found no associations with the quality of the home learning environment (Rosales-Rueda, 2014). Research in developmental psychology has investigated only a few restricted characteristics of children that predict home learning environment quality like race/ethnicity and birth order (Bradley et al., 2001; Dearing & Taylor, 2007). In short, although theoretical models support the hypothesis that poor early health may inhibit children's exposure to enriching home environments, little empirical support exists.

A second possibility is that learning opportunities serve a moderating rather than mediating role connecting children's physical health and early development. Drawing on bioecological theory (Bronfenbrenner & Morris, 1998), the present study conceptualizes physical health as a "person" characteristic that interacts with children's environments,

such as the home learning environment or ECE, to influence the proximal processes involved in development. One hypothesis to emerge from this framework argues that the learning opportunities afforded by ECE may help sick children compensate for health-related impairments. Along these lines, studies often find that high-quality and center-based ECE plays a compensatory role for socioeconomically disadvantaged children (Caughy, DiPietro, & Strobino, 1994; Miller, Farkas, Vandell, & Duncan, 2014; Votruba-Drzal et al., 2013; Watamura et al., 2011), such that children who start with lower levels of functioning show greater gains in skills as a result of participation in ECE. Limited attention has been paid to whether center-based ECE experiences interact with specific child characteristics. Some studies in this arena[1] find that children with characteristics associated with more limited self-regulatory skills (such as difficult temperament or male gender) may benefit more than other children from promotive ECE experiences (Crockenberg, 2003; Pluess & Belsky, 2010; Votruba-Drzal, Coley & Chase-Landsdale, 2004). Thus, early learning opportunities may protect against the negative effects of health problems on school readiness skills through the provision of supportive learning environments.

An alternative hypothesis to emerge from the bioecological model is that children in poor health might be hindered in the extent to which they can fully engage in or benefit from the rich learning environments afforded to children in these contexts; thus, engagement in early learning contexts would function as a potentiating force that further exacerbates developmental differences in children. Research on children's health and

[1] Most of these studies examine the effects of child care quality. On the whole, center-based ECE shows the highest process-related quality across types of child care arrangements (Dowsett, Huston, Imes, & Gennetian, 2008; Magnuson & Waldfogel, 2005), and generally reflects participation in a high quality ECE setting.

parents' caregiving suggests that children experiencing health problems may struggle to fully engage in supportive and reciprocal interactions with primary caregivers (Barrera et al., 1986; Zelkowitz & Papgeorgiou, 1996). For instance, children with ear infections may be unable to hear or understand instructions; children with asthma may need medical attention that reduces time spent on learning tasks and activities; and children who wheeze or have respiratory infections may be limited to non-physical activities that prevent social interactions with peers, family members, or teachers (Currie, 2005). Such experiences may inhibit the benefits children receive from learning experiences in both ECE and home contexts. Yet, no past research has explicitly examined whether children's time in ECE or engagement in home learning activities moderates the associations between physical health problems and school readiness skills.

Associations Across the Family Socioeconomic Spectrum

A final important theme to acknowledge at the fulcrum of children's physical health, early learning opportunities, and school readiness skills is the role of distal family socioeconomic (SES) resources like household income and maternal education, which have shown robust links with children's health and development across the social science literature. Family income and maternal education are central to families' capacities to provide children with resources, such as health care and home learning materials, and to leverage their knowledge, for example, about the signs of illnesses and the value of ECE for children's development. Research finds that children growing up in families with either low income or low maternal education exhibit higher rates of neonatal health problems, worse general physical health, and a higher likelihood of chronic and acute health problems (Braveman & Barclay, 2009; Brooks-Gunn & Duncan, 1997; Currie,

2005), as well as lower cognitive and behavioral skills at school entry (Christian, Morrison, & Bryant 1998; Duncan & Magnuson, 2005), on average, than children from middle and upper-class families. These studies highlight the widening socioeconomic disparities across domains of child functioning and draw attention to the need for research examining whether family resources may protect children against the negative developmental repercussions of early health problems.

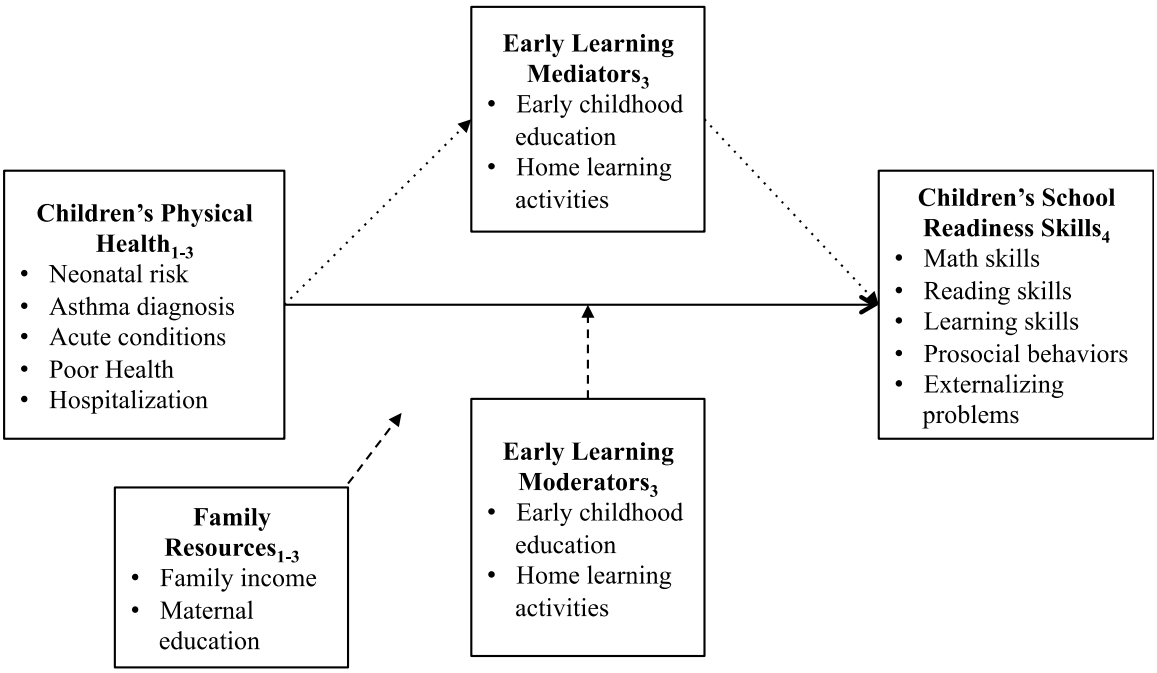
Despite the well-established evidence of socioeconomic disparities across children's health, early learning opportunities, and development, little extant research has attended to the role of family resources at the intersections of these domains. An exception is a study conducted by Figlio and colleagues (2013), who analyzed birth weight differences in twins and found negative associations between low birth weight and cognitive skills across elementary school, with similar patterns across socioeconomic strata. These findings suggest that the ramifications of neonatal risks, which may have immediate and long-term effects on children's neurobiological functioning, are population-level public health concerns. Yet, no research has examined whether such patterns are replicated with a range of other health indicators or developmental outcomes. Furthermore, few studies have examined whether relations between children's health and parental investments in children differ across the resource spectrum, but Hsin (2009) found that more educated mothers spent more time engaged in learning opportunities with low birth weight children, where as less educated mothers invested more in children of higher birth weight. These results provide support for the possibility that the mediating role of early learning contexts linking health and development function differently across the family resource spectrum.

There is also a substantial body of literature asserting that the benefits of early learning contexts are strongest for socioeconomically disadvantaged children who have the most to gain from structured and supportive learning environments (Christian et al., 1998; Gormley & Gayer, 2005; Loeb et al., 2004; Magnuson et al., 2004; Magnuson, Sexton, Davis-Kean, & Huston, 2009; Winsler et al., 2004), but who are also less likely than their more advantaged peers to attend center-based ECE or have high quality home learning environments (Bradley, 2002; Capizzano & Adams, 2004; Early & Burchinal, 2001). Despite this extensive literature, it is unknown whether family SES may alter the mediating or moderating roles of early learning contexts in relation to children's health and school readiness. Considering the distinct socioeconomic gradients in children's functioning and their access to early learning opportunities, an examination of whether the processes linking health and school readiness differ by level of family resources is clearly warranted.

Present Study

To summarize, extant literature on children's early health conditions has paid limited attention to the range of physical health problems that may be salient early in life, the potential pathways through which early physical health problems may be related to the emergence of school readiness skills, and the possibility that family SES may moderate these hypothesized associations. The conceptual model underlying this dissertation is presented in Figure 1. Mediating pathways are presented as dotted lines, and moderating associations are presented as dashed lines.

Figure 1. Conceptual Model



The first goal of this dissertation is to establish whether direct associations exist linking early physical health problems and school readiness skills.

Research Question 1. Do early physical health problems directly predict school readiness skills?

Hypothesis 1. Based on prior evidence linking children's physical health to greater deficits in functioning in adolescence and adulthood (Black et al., 2005; Case & Paxson, 2010; Currie & Hyson, 1999), heightened health problems will predict lower school readiness skills, particularly lower cognitive skills.

The second goal aims to identify theoretically informed pathways through which physical health might explain disparities in school readiness skills by examining whether participation in home learning activities or time in ECE mediate the associations tested in Research Question 1.

Research Question 2. Does restricting development-promoting opportunities in ECE or home learning environments among children in poor health indirectly explain the associations between physical health problems and school readiness skills?

Hypothesis 2. Drawing on the transactional-ecological model of development arguing that parents respond to their children's characteristics and behaviors in ways that may either promote or impair development (Sameroff & Chandler, 1975), it is hypothesized that the relationship between physical health problems and school readiness skills will be explained by the decreased access of children in poor health to participate in ECE or home learning activities (Early & Burchinal, 2000). Lack of access to these learning opportunities in turn will predict lower school readiness skills.

The third goal of this dissertation addresses the possibility that associations between health problems and school readiness are contingent on children's engagement in early learning opportunities in the home or in ECE.

Research Question 3. Does engagement in home learning activities or participation in ECE temper the negative associations between children's physical health problems and school readiness skills, such that early learning opportunities serve a protective role for children in poor health, or further exacerbate existing associations?

Hypothesis 3. It is hypothesized that early learning opportunities will attenuate the negative associations between physical health problems and

the development of school readiness competencies (Pluess & Belsky, 2010; Votruba-Drzal et al., 2004), with home learning and ECE benefits more pronounced for children in poor health than for their peers without health problems.

The final aim explores whether relations between children's health, development, and early learning vary across the family socioeconomic spectrum.

Research Question 4. Do family income and maternal education moderate the direct associations (Research Question 1), indirect associations (Research Question 2), or interacted associations (Research Question 3) linking children's physical health problems and school readiness skills?

Hypothesis 4a. The literature on health disparities suggests that greater family SES will protect against the negative direct effects of health problems on school readiness skills while lower family SES will exacerbate this association (Braveman & Barclay, 2009).

Hypothesis 4b. It is hypothesized that low SES children with health problems who experience less time in ECE or fewer home learning activities will perform worse on measures of school readiness than higher SES children with similar levels of participation and engagement in early learning opportunities.

Hypothesis 4c. Potential benefits of ECE and home learning opportunities for children with physical health problems are hypothesized to be stronger for children in families with lower SES than for higher SES children (Geoffroy et al., 2010; Watamura et al., 2011).

CHAPTER 3: RESEARCH DESIGN

Sample

Data were drawn from the Early Childhood Longitudinal Study-Birth Cohort (ECLS-B), a multi-method prospective birth cohort study that followed a sample of approximately 10,700 children[2] born in the United States in 2001 from infancy through kindergarten (Flanagan & West, 2004). The ECLS-B sample is nationally representative of the 4 million children born in the United States in 2001 excluding children born to mothers who were less than 15 years old and children who were adopted or had died prior to the first interview.

Data were first collected in 2001 through interviews with the primary caregiver (98% biological mothers; hereafter referred to as "parent") and child assessments when focal children averaged 10 months old. Families were re-interviewed in 2003-2004 when children were 2 years old, in 2005-2006 when children were 4 years old (preschool), and in 2006 when most children were 5 years old and had entered kindergarten. Weighted response rates across each wave of data collection were 74.1% at the 10-month wave (Wave 1; N = 10,700), 93.1% at the 2-year wave (Wave 2; N = 9,850), 91.3% at the preschool wave (Wave 3; N = 8,900) 91.8% at the kindergarten 2006 wave (N = 6,950). At each wave, parents were interviewed in English or Spanish, with translators used for other languages. Data were also collected through direct assessments of children's math and reading skills, and through preschool teacher (92% response rate) and kindergarten teacher (76% response rate) reports of children's social and behavioral functioning in the classroom. The analytic sample was limited to children whose families participated in

[2] Ns rounded to nearest 50, per NCES reporting requirements.

the study through Wave 4 and who were not reported to experience severe physical health problems such as blindness, cerebral palsy, or Down's Syndrome, among other conditions, yielding an analytic sample of approximately 5,900 children.

Measures

School readiness outcomes. Children's school readiness skills were assessed at Wave 4 when most children (77%) had entered kindergarten. Pre-academic skills were directly assessed by trained interviewers using tests of math and reading skills. Items for math and reading tests were drawn from well-validated measures such as the Test of Early Mathematics Ability-3 (TEMA-3; Ginsburg & Baroody, 2003), PreLAS 2000 (Duncan & DeAvila, 1998), Peabody Picture Vocabulary Test-Third Edition (PPVT-III; Dunn & Dunn, 1997), and Preschool Comprehensive Test of Phonological and Print Processing (Pre-CTOPPP; Lonigan, Wagner, Togesen & Rashotte, 2002), as well as items created specifically for the ECLS-B. Tests were individually administered and were scored based on item-response theory procedures. The math assessment contained 58 items ($\alpha = .92$) that captured children's number sense, properties and operation, measurement, spatial sense, probability, and patterns. The reading assessment contained 74 items ($\alpha = .92$) and covered vocabulary, letter knowledge, word recognition, print conventions, and phonological awareness.

Children's behavioral functioning and attention skills were assessed using teacher reports on items drawn from the Preschool and Kindergarten Behavior Scales (PKBS-2; Merrell, 2003), the Social Skills Rating System (SSRS; Gresham & Elliott, 1990), and the ECLS-K. Learning skills were captured using six items such as "child pays attention well" and "child works/plays independently" on a 5-point scale from *not true* to *very true*

(α = .89). Prosocial behaviors were measured using six items like "child makes friends easily" and "child is accepted by other children" on a 5-point scale from *not true* to *very true* (α = .87). Externalizing problems were assessed using seven items like "child has temper tantrums" and "child is physically aggressive" (α = .92) on a 5-point scale from *never* to *very often*.

Physical health indicators. Five distinct aspects of early childhood physical health were drawn from birth certificates and from parental reports between Waves 1 through 3. Information on children's birth weight and gestational age at birth were identified using birth certificate data. These items were coded to capture risk, delineating children of low birth weight (<2500 grams) and premature birth (before 37 weeks' gestation), and were combined into a single dichotomous variable indicating any neonatal risk. At each wave, mothers reported whether their child was diagnosed with asthma since the prior interview. Parents also reported at each wave whether their child was ever diagnosed with acute health conditions including ear infections and respiratory illnesses, and for ear infections, how many times their child was diagnosed. Due to data collection limitations, parents could only report on the number of times the child was diagnosed with a respiratory infection at Wave 3. Additionally, mothers reported each wave on children's global health status on a scale ranging from 1 = *excellent* to 5 = *poor*. As suggested by Currie et al. (2008), a dichotomous indicator was created to address the skewness of this variable with children reported to be in good, fair, or poor health categorized as in suboptimal (poor) global health. Finally, at each wave parents reported whether the child had been hospitalized since the prior interview; hospitalization is seen as a proxy for the severity of health conditions. For asthma diagnosis, poor health, and

hospitalization, data were drawn from Waves 1 through 3 to create dichotomous indicators for whether parents reported that the child ever experienced each of these health conditions from birth through age 4. For acute conditions, parents' reports of their children's ear infection and respiratory illnesses were summed across Waves 1 through 3 to assess the frequency of these conditions.

ECE participation. Across the first three waves, mothers reported the number of hours that children spent in center-based care or early education programs (private, public, and Head Start programs). Within each wave, variables for hours spent in center care were topcoded to two standard deviations above the mean to address a substantial skew and divided by 10 for ease of interpretation. Additionally, these variables were also averaged across the first three waves to capture average time in center care or ECE.

Home learning activities. Mothers also reported at the first three waves on items drawn from the Short Form of the Home Observation for Measurement of the Environment Inventory (Caldwell & Bradley, 2001), the National Household Education Survey (NHES), and items created for the ECLS-B capturing developmentally appropriate learning activities. At Wave 1, mothers reported on 7 items such as providing toys or singing songs to the child. At Waves 2 and 3, home learning activities were assessed using 23 items and 18 items, respectively, capturing experiences such as visits to the library, the number of books belonging to the child, parents' time spent reading with the child, and child's participation in arts and crafts. Items were standardized and averaged within wave to create composite variables ($\alpha_{1\text{-}3}$ = .60-.73) capturing each child's access to and engagement in a range of developmentally

appropriate learning opportunities. An average composite drawing on data across the first three waves was also constructed.

Family socioeconomic resources. At each wave, mothers reported on total household income in the prior year and their highest level of education. Household income was coded in relation to family size and poverty threshold for a measure of income-to-needs and was averaged across Waves 1 to 3 to increase measurement reliability. Family income was also categorized at less than 100% of the poverty line, 100% to 200%, 200 to 300%, and greater than 300%. Additionally, mothers reported on the highest level of their educational attainment, which was operationalized continuously using an ordinal variable which ranged from 1 = *less than 8th grade* to 9 = *doctorate or professional degree*, and categorically as less than high school, high school or GED, some additional training beyond high school, or a college degree or higher.

Covariates. Numerous child, maternal, and family characteristics were assessed and included in multivariate analyses to address concerns of omitted variable bias. These characteristics were chosen based on prior theoretical and empirical evidence of their relations with child health and development. Covariates included child gender, child's age in months at Wave 3, twin or triplet status, ADHD diagnosis, Autism Spectrum diagnosis, and months of exposure to kindergarten prior to the Wave 4 assessment. Children's race/ethnicity was described as non-Hispanic White, non-Hispanic Black, Asian/Pacific Islander, Native American or multi-racial. Mothers also reported on the child's enrollment in either private health insurance or government funded health insurance programs (e.g., Medicaid, Children's Health Insurance Program), which were

combined into a categorical variable indicating whether the child always had private insurance, always had public, or had unstable health insurance between Waves 1 and 3.

Maternal and family covariates included maternal age at Wave 3, family immigrant status (a dichotomous indicator for whether either parent was born outside of the U.S.), primary household language other than English, highest level of maternal education (coded as less than high school, high school or GED, some college or professional school, or a college degree or higher), as well as yearly household income and the number of minors in the household, which were averaged across Waves 1 through 3. Additional family structure and human capital characteristics included maternal employment (employed vs. not), receipt of public assistance (indicated by receipt of Temporary Assistance for Needy Family, Supplemental Nutrition Assistance Program, or Women, Infants and Children), and maternal marital status (married vs. not). These time-varying covariates were operationalized categorically to indicate whether mothers reported being employed, receiving public assistance, and being married at all waves (1 through 3), some waves, or no waves of data collection. This coding captures stability and change in parental human capital characteristics and reflects the notion that children's school readiness skills are determined by the accumulation of their early inputs (NICHD ECCRN & Duncan, 2003). This practice of computing longitudinal covariates across multiple waves of data has been employed in other studies using ECLS-B data (Coley et al., 2013).

Additional covariates also assessed child and maternal functioning, maternal work hours, and the children's exposure to peers in non-parental care settings. Children's early cognitive ability was assessed at Wave 1 using the Bayley Short Form-Research Edition

(BSF-R; Bayley, 1993), which assessed early abilities in the domains of objects and pre-verbal communication, and were scored using item-response theory procedures to create an overall score of early mental ability ($\alpha = .80$). Children's temperament was assessed at Wave 1 using mother and interviewer-report items from the Infant/Toddler Checklist (ITSC; DeGangi, Poisson, Sickel & Wiener, 1995) and the Behavior Rating Scale (BRS), which is a component of the Bayley Scales of Infant Development (BSID-II; Bayley, 1993). Items measured children's self-regulation, engagement, and attention, and were combined into a composite of general adaptability (15 items, $\alpha = .70$). Maternal psychological distress was averaged across Waves 1 and 3 using the 12-item Center for Epidemiological Studies Depression Scale, Short Form (CES-D Short; Radloff, 1997; $\alpha_{1\text{-}3} = .87\text{-}.89$). Parents responded using items asking how often in the past week they "could not shake off the blues" and "were lonely." At Wave 3, mothers reported on the total number of hours per week they usually worked for pay. Finally, children's exposure to peers in non-parental care was assessed through parent reports at each interview. Parents reported the type of non-parental care that the child received and the number of children cared for in each of these settings. Across care settings, child exposure was summed within wave and then averaged across Waves 1 to 3.

Analytic Approach

All analyses were conducted in Mplus Version 6.1 (Muthén & Muthén, 2010) using full information maximum likelihood (FIML) to address concerns about item-level missing data. Missing data analysis revealed less than 2% missing on child health, less than 1% missing on early learning opportunities, 2% to 30% missing on school readiness outcomes, and less than 8% missing on covariates. Evidence generally indicated that

data were missing at random due to study attrition, supporting the use of FIML (Enders, 2012). Analyses incorporated the National Center for Education Statistics (NCES) replicate population weights, applied using jackknife survey estimation (Asparouhov & Muthen, 2010), to adjust for differential selection into and retention in the sample and to make the analytic sample representative of the population of children born in the United States in 2001.

In line with the first aim, linear regression analyses were used to identify direct associations between children's physical health problems assessed across the first four years of life and school readiness skills at age 5. Prior to selection of final models, an exhaustive series of models were explored to best capture indicators of children's health, to understand relations between health variables, and to test the robustness of effects to the inclusion of increasingly rigorous covariates. This process is detailed in Appendix A. As shown in Equation 1, each of the school readiness outcomes were regressed on the five health indicators and a set of covariates. Final analyses controlled for a rich array of covariates that included child age, gender, twin status, autism and ADHD diagnoses, months of kindergarten exposure, maternal age, education, employment, marital status, family income, non-English speaking household, immigrant household, public assistance receipt, and child health insurance receipt.

Equation 1. $SchoolReadiness = \alpha_1 + \beta_1(PhysicalHealth) + \gamma\ (Covariates) + e$

The second aim testing whether the associations between children's health and school readiness functioned indirectly through early learning opportunities, used path analyses, shown in Equation 2. Early learning contexts included home learning activities and time in ECE, measured contemporaneously and drawn from Wave 3, given the

developmental importance of early learning opportunities in the year prior to kindergarten entry (Gormley & Gayer, 2005; Votruba-Drzal et al., 2013). Model fit was assessed using the model χ^2, Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and the Standardized Root Mean Square (SRMR). For the absolute fit indices, which assess the extent to which an a priori model can be replicated in the sample data, Hu and Bentler (1999) recommend thresholds of 0.08 for the RMSEA and 0.06 for the SRMR as indicators of good model fit. For the incremental fit indices, which capture improvements in fit between the hypothesized model and a nested baseline model, Hu and Bentler recommend 0.90 for the CFI and TLI. After adjusting models based on modification indices, analyses estimated the indirect effects of children's health problems on school readiness skills through home and ECE contexts. Based on the methodological literature citing the importance of appropriately quantifying indirect effects and testing for statistical significance (Dearing & Hamilton, 2006; Hayes, 2009; MacKinnon, Fairchild, & Fritz, 2007), all path analyses incorporated bootstrapping (n =10,000). This process draws repeated artificial samples with replacement from the analytic sample so that estimated coefficients and standard errors can be used to identify a point estimate for the indirect effect as well as a standard error of the estimate and reliable confidence intervals (Dearing & Hamilton, 2006).

Equation 2.

$$ECE = \alpha_1 + \beta_1(PhysicalHealth) + \gamma\ (Covariates) + e_1$$

$$HomeLearning = \alpha_2 + \beta_1(PhysicalHealth) + \gamma\ (Covariates) + e_2$$

$$SchoolReadiness = \alpha_3 + \beta'_1(PhysicalHealth) + \beta_2(ECE) + \beta_3(HomeLearning) + \gamma\ (Covariates) + e_3$$

The third aim sought to test whether early learning opportunities moderated associations between children's physical health and school readiness skills. As demonstrated in Equation 3, interaction terms between child health variables and home and ECE contexts were included in a single model, with all continuous independent variables mean-centered to reduce multicollinearity (Dearing & Hamilton, 2006).

Equation 3. $SchoolReadiness = \alpha_1 + \beta_1(PhysicalHealth) + \beta_2(ECE) + \beta_3(HomeLearning) + \beta_4(PhysicalHealth * ECE) + \beta_5(PhysicalHealth * HomeLearning) + \gamma\ (Covariates) + e$

In order to test the fourth aim exploring moderation by family SES, the models described in Equations 1 through 3 were replicated in models separately testing interactions terms for family income or maternal education. For models testing whether family SES moderated direct associations between health and school readiness, analyses included interactions between children's health and family SES, as shown in Equation 4 with family income, with all continuous variables mean-centered to reduce multicollinearity among predictor variables (Dearing & Hamilton, 2006).

Equation 4. $SchoolReadiness = \alpha_1 + \beta_1(PhysicalHealth) + \beta_2(FamilyIncome) + \beta_3(PhysicalHealth * FamilyIncome) + \gamma\ (Covariates) + e$

By quantifying the indirect effect, described in regard to the second aim, it is also possible to test whether mechanisms linking children's health and development are contingent on family SES, which is a process called moderated mediation or conditional process analysis (Hayes, 2013). In these models, interaction terms between health and family SES are added as predictors of the mediators, and interactions terms between health, the mediators, and family SES are added as predictors of school readiness, shown

in Equation 5 with family income. Adding these interactions terms indicates whether any of the paths in the proposed model differ by family SES and permits significance testing of the indirect effect across levels of family SES. Like the models presented in Equation 2, these models were estimated with bias corrected bootstrapped confidence intervals.

Equation 5. $ECE = \alpha_1 + \beta_1(PhysicalHealth) + \beta_2(FamilyIncome) + \beta_3(PhysicalHealth*FamilyIncome) + \gamma\ (Covariates) + e_1$

$HomeLearning = \alpha_2 + \beta_1(PhysicalHealth) + \beta_2(FamilyIncome) + \beta_3(PhysicalHealth*FamilyIncome) + \gamma\ (Covariates) + e_2$

$SchoolReadiness = \alpha_3 + \beta'_1(PhysicalHealth) + \beta_2(ECE) + \beta'_3(HomeLearning) + \beta'_4(FamilyIncome) + \beta'_4(PhysicalHealth*FamilyIncome) + \gamma\ (Covariates) + e_3$

A final set of models examined whether the moderating effect of learning contexts on the associations between health and school readiness was conditional on the level of family SES. These models replicated the models depicted in Equation 3 with interactions for family SES. These three-way interactions models were conducted separately for family income and maternal education, as shown in Equation 6 for family income.

Equation 6. $SchoolReadiness = \alpha_1 + \beta_1(PhysicalHealth) + \beta_2(ECE) + \beta_3(HomeLearning) + \beta_4(FamilyIncome) + \beta_5(PhysicalHealth * ECE) + \beta_6(PhysicalHealth * HomeLearning) + \beta_7(PhysicalHealth * FamilyIncome) + \beta_8(ECE * FamilyIncome) + \beta_5(HomeLearning * FamilyIncome) + \beta_5(PhysicalHealth * ECE * FamilyIncome) + \beta_5(PhysicalHealth * HomeLearning * FamilyIncome) + \gamma\ (Covariates) + e$

CHAPTER 5: RESULTS

Sample Characteristics

Weighted descriptive statistics for the full analytic sample are presented in Table 1. Within this sample, 7% of children were reported to have a neonatal risk, with 7% born with low birth weight (< 2500 grams) and 2% born prematurely before 37 weeks' gestation. Preliminary descriptive analyses showed relative stability at the population level for children's suboptimal health, rates of hospitalization, and acute illnesses from infancy through preschool years, with some indication of linear increases in asthma diagnoses. Between birth and 4 years of age, 14% of children had been diagnosed with asthma and 13% were hospitalized for health problems related to either asthma or respiratory infections. On average, children had experienced less than four acute conditions, such as respiratory and ear infections. Parents reported that nearly 25% of children were in suboptimal health at some point during the first four years of life. Health and developmental indicators, as well as early learning opportunities, were modestly but statistically significantly correlated (Table 2).

Table 1. Weighted Descriptive Statistics

	M/% (SD)	Min	Max
School Readiness Skills			
Math Skills	41.40 (10.15)	11.10	69.69
Reading Skills	39.57 (14.68)	12.39	82.48
Learning Skills	3.93 (0.74)	1	5
Prosocial Behaviors	3.87 (0.66)	1	5
Externalizing Problems	1.93 (0.80)	1	5
Child Health Indicators			
Neonatal Risks	0.07	0	1
Premature Birth	0.02	0	1
Low Birth Weight	0.07	0	1
Asthma Diagnosis$_{1-3}$	0.14	0	1
Wave 1	0.04	0	1
Wave 2	0.09	0	1
Wave 3	0.14	0	1
Acute Conditions Diagnoses	3.61 (4.35)	0	21.61
Wave 1	1.13 (1.84)	0	21.00
Wave 2	1.37 (2.13)	0	34.00
Wave 3	1.22 (2.39)	0	40.00

Poor Global Health	0.24		0	1
Wave 1	0.10		0	1
Wave 2	0.11		0	1
Wave 3	0.12		0	1
Hospitalization$_{1-3}$	0.13		0	1
Wave 1	0.06		0	1
Wave 2	0.06		0	1
Wave 3	0.05		0	1
Early Learning Opportunities				
Home Learning Activities$_{3}$	-0.00	(0.42)	-1.27	1.81
Home Learning Activities$_{1-3}$	0.06	(0.35)	-1.54	1.31
Hours in ECE (10 hours)$_{3}$	1.55	(1.58)	0	5.10
Hours in ECE (10 hours)$_{1-3}$	0.07	(0.08)	0	0.35
Family Resources (Continuous)				
Family Income to Needs	3.10	(2.48)	0.08	13.67
Maternal Education	4.56	(1.85)	1	9
Covariates				
ADHD Diagnosis	0.01		0	1
Autism Diagnosis	0.01		0	1
Multiple Birth	0.03		0	1
Kindergarten Exposure	2.26	(1.84)	0	7
Child Age (months)	52.34	(3.93)	44	65.30
Child Race				
White	0.54		0	1
Black	0.14		0	1
Hispanic	0.27		0	1
Asian/Pacific Islander	0.03		0	1
Multiracial	0.04		0	1
Child Gender (male)	0.51		0	1
Household Income ($10k)	5.77	(4.36)	0.25	20.00
Maternal Education				
Less than High School	0.15		0	1
Hgh School/GED	0.27		0	1
Some College	0.33		0	1
College/Advanced Degree	0.25		0	1
Maternal Age (years)	32.15	(6.58)	17	74
Non-English Household	0.20		0	1
Immigrant Household	0.25		0	1
Mother is Married				
Always	0.64		0	1
Sometimes	0.11		0	1
Never	0.25		0	1
Minors in Household	2.22	(1.03)	1	6
Child Health Insurance				
Always Private	0.47		0	1
Always Public	0.34		0	1
Unstable Arrangement	0.19		0	1
Maternal Employment				
Always	0.38		0	1
Sometimes	0.36		0	1
Never	0.25		0	1
Public Assistance Receipt				
Always	0.32		0	1
Sometimes	0.23		0	1
Never	0.44		0	1
Additional Covariates				
Maternal Psychological Distress$_{1-3}$	4.89	(4.47)	33.84	126.34
Child Mental Skills$_{1}$	76.99	(9.75)	33.84	126.34
Child Temperament$_{1}$	0.08	(0.50)	-1.87	1.28
Maternal Work Hours$_{3}$	21.28	(20.07)	0	99.00
Peer Exposure$_{1-3}$	8.16	(5.82)	0	59.00

Table 2. Sample Correlations

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. Math Skills	1.00																		
2. Reading Skills	0.82**	1.00																	
3. Learning Skills	0.35**	0.31**	1.00																
4. Prosocial Behaviors	0.21**	0.20**	0.63*	1.00															
5. Externalizing Problems	-0.21**	-0.20**	-0.64**	-0.43**	1.00														
6. Neonatal Risks	-0.14**	-0.10**	-0.08**	-0.03+	0.04*	1.00													
7. Asthma Diagnosis	-0.07**	-0.07**	-0.05**	-0.03+	0.05**	0.08**	1.00												
8. Acute Conditions	-0.02	-0.03*	-0.06**	-0.01	0.08**	0.04**	0.21**	1.00											
9. Poor Global Health	-0.10**	-0.09**	-0.07**	-0.06**	0.03+	0.04**	0.22**	0.13**	1.00										
10. Hospitalization	-0.10**	-0.09**	-0.08**	-0.05**	0.08**	0.09**	0.46**	0.25**	0.16**	1.00									
11. Home Learning Activities	0.19**	0.17**	0.14**	0.14**	-0.09**	-0.01	-0.02+	0.06**	-0.17**	-0.02+	1.00								
12. Hours in ECE	0.09**	0.11**	-0.05**	-0.01	0.10**	0.01	0.08**	0.12**	0.02	0.06**	-0.04**	1.00							
13. Family Income to Needs	0.41**	0.39**	0.18**	0.12**	-0.12**	-0.05**	-0.11**	-0.02	-0.14*	-0.10**	0.26**	0.10**	1.00						
14. Maternal Education (years)	0.40**	0.38**	0.18**	0.09**	-0.09**	-0.02	-0.08**	0.01	-0.16**	-0.06**	0.31**	0.13**	0.63**	1.00					
15. ADHD Diagnosis	-0.06**	-0.05**	-0.09**	-0.06**	0.10**	0.03*	0.06**	0.02+	0.03*	0.05**	-0.01	0.02	-0.05**	-0.05**	1.00				
16. Autism Diagnosis	0.02	0.03**	-0.04**	-0.05**	0.03*	0.01	0.01	0.04**	0.00	0.02	0.03*	0.01	0.04**	0.04**	0.07**	1.00			
17. Multiple Birth	-0.07**	-0.06**	-0.01	0.03+	-0.01	0.37**	-0.03*	0.02+	-0.07**	-0.01	0.03*	-0.02	0.08**	0.02+	-0.02	0.01	1.00		
18. Kindergarten Exposure	0.34**	0.41**	-0.08**	-0.01	-0.02	-0.01	0.03+	0.00	0.04**	-0.01	-0.05**	0.05**	-0.05**	-0.02	0.02	0.02	-0.05**	1.00	
19. Child Age (months)	0.29**	0.29**	-0.03+	-0.02	-0.03*	-0.01	0.03**	0.01	0.05**	-0.01	-0.09**	0.09**	-0.05**	-0.03+	0.02	-0.01	-0.02	0.51**	1.00
20. Child is White	0.11**	0.05**	0.07**	0.09**	-0.00	0.11*	-0.08**	0.16**	-0.15**	-0.02	0.25**	-0.08**	0.20**	0.22**	-0.01	0.00	0.24**	-0.09**	-0.07**
21. Child is Black	-0.17**	-0.12**	-0.12**	-0.04**	0.09**	0.10**	0.14**	-0.05**	0.03*	0.09**	-0.14**	0.20**	-0.13**	-0.22**	0.05**	-0.02	-0.02	-0.02	-0.03*
22. Child is Hispanic	-0.17**	-0.15**	-0.05**	-0.03*	-0.01	-0.04**	0.01	-0.05**	0.13**	-0.01	-0.16**	-0.10**	-0.30**	-0.22**	0.01	0.03*	-0.07**	0.08**	0.07**
23. Child is Asian/Pacific Islander	0.19**	0.19**	0.07**	-0.06**	-0.08**	-0.16**	-0.05**	-0.13**	0.06**	-0.06**	-0.07**	0.03*	0.16**	0.15**	-0.03**	-0.02	-0.17**	0.05**	0.05**
24. Child is Multiracial	0.02	0.01	0.00	0.01	0.01	-0.07**	0.02	0.02+	-0.04**	0.01	0.05**	-0.01	0.04**	0.02	-0.01	0.00	-0.07**	-0.00	-0.00
25. Child is Male	-0.03*	-0.06**	-0.20**	-0.18**	0.27**	-0.06**	0.07**	0.05**	0.07**	0.05**	-0.03**	-0.00	0.00	0.00	0.02	0.03*	-0.02	-0.02+	-0.00
26. Household Income ($10k)	0.40**	0.37**	0.18**	0.12**	-0.13**	-0.03*	-0.12**	-0.01	-0.14**	-0.10**	0.25**	0.07**	0.63**	0.97**	-0.05**	0.03*	0.10**	-0.02	-0.03*
27. Mother Less than High School	-0.24**	-0.22**	-0.08**	-0.06**	0.02	0.01	0.04**	-0.03*	0.13**	0.03*	-0.22**	-0.10**	-0.59**	-0.31**	0.02+	-0.02	-0.07**	0.03*	0.05**
28. Mother High School/GED	-0.17**	-0.16**	-0.11**	-0.05**	0.06**	0.02+	0.05**	-0.02	0.05**	0.02+	-0.14**	-0.02	-0.47**	-0.29**	0.03*	-0.01	-0.03*	0.02+	0.02
29. Mother Some College	-0.01	-0.02	-0.03	-0.00	0.05**	0.00	0.01	0.07**	-0.04**	0.03*	0.06**	0.01	0.13**	-0.07**	0.01	-0.01	0.02	-0.01	-0.03*
30. Mother College+	0.35**	0.34**	0.19**	0.09**	-0.12**	-0.03*	-0.09**	-0.03*	-0.11**	-0.07**	0.24**	0.08**	0.75**	0.58**	-0.05**	0.04**	0.06**	-0.03*	-0.02
31. Maternal Age	0.22**	0.19**	0.09**	0.01	-0.07**	0.01	-0.08**	-0.03*	-0.08**	-0.07**	0.10**	-0.01	0.34**	0.37**	-0.03**	0.02+	0.11**	0.03*	0.03*
32. Non-English Household	0.06**	0.06**	0.05**	-0.05**	-0.10**	-0.13**	-0.06**	-0.17**	0.17**	-0.09**	-0.21**	-0.08**	-0.10**	-0.04**	-0.01	0.01	-0.14**	0.09**	0.10**
33. Immigrant Household	0.11**	0.12**	0.07**	-0.04*	-0.13**	-0.14**	-0.06**	-0.17**	0.13**	-0.10**	-0.14**	-0.07**	0.01	0.07**	-0.02	0.01	-0.16**	0.08**	0.09**
34. Mother Always Married	0.27**	0.24**	0.19**	0.11**	-0.15**	-0.07**	-0.14**	-0.04**	-0.10**	-0.12**	0.18**	-0.13**	0.37**	0.43**	-0.07**	-0.00	0.09**	-0.04**	-0.05**
35. Mother Sometimes Married	-0.05**	-0.05**	-0.06**	-0.02	0.06**	0.03+	0.05**	0.06**	0.01	0.03*	-0.04**	0.04**	-0.12**	-0.13**	0.03	-0.02	-0.04**	0.05**	0.07**
36. Mother Never Married	-0.27**	-0.23**	-0.17**	-0.10**	0.12**	0.06**	0.12**	0.00	0.11**	0.12**	-0.17**	0.11**	-0.33**	-0.38**	0.06**	0.02	-0.07**	0.02	0.01
37. Minors in Household	-0.19**	-0.21**	-0.05**	-0.03*	-0.02	0.08**	0.03*	0.02	0.04**	0.03*	-0.12**	-0.11**	-0.17**	-0.28**	0.01	-0.03**	0.31**	-0.01	-0.01
38. Child Always Private Insurance	0.32**	0.29**	0.16**	0.09**	-0.12**	-0.05**	-0.11**	-0.02	-0.14**	-0.11**	0.22**	-0.01	0.51**	0.62**	-0.04**	0.01	0.08**	-0.03**	-0.04**
39. Child Always Public Insurance	-0.29**	-0.26**	-0.15**	-0.08**	0.12**	0.05**	0.13**	0.03*	0.12**	0.10**	-0.18**	0.05**	-0.43**	-0.50**	0.06*	-0.00	-0.05**	0.02	0.00
40. Child Unstable Health Insurance	-0.06**	-0.06**	-0.02	-0.01	0.00	-0.00	-0.01	-0.02	0.03**	0.01	-0.06**	-0.05**	-0.13**	-0.19**	-0.02	-0.01	-0.04**	0.03+	0.05**
41. Mother Always Employed	0.13**	0.12**	0.04*	0.04*	0.01	-0.03*	-0.02	0.06**	-0.05**	-0.01	-0.04**	0.22*	0.21**	0.25**	-0.02	0.02	-0.04**	0.02+	0.01
42. Mother Sometimes Employed	-0.08**	-0.07**	-0.06**	-0.04**	0.05**	0.02+	0.06**	0.01	0.04**	0.04**	-0.02	-0.02	-0.10**	-0.18**	0.01	-0.01	-0.00	0.01	0.04**
43. Mother Never Employed	-0.05**	-0.05**	0.03*	0.00	-0.07**	0.01	-0.04**	-0.08**	0.01	-0.03*	0.06**	-0.23**	-0.12**	-0.07**	0.01	-0.01	0.05**	-0.04**	-0.05**
44. Always Public Assistance	-0.32**	-0.29**	-0.17**	-0.09**	0.12**	0.03**	0.13**	0.02+	0.13**	0.12**	-0.20**	0.03*	-0.46**	-0.53**	0.07**	-0.02+	-0.04**	-0.00	0.00
45. Sometimes Public Assistance	-0.07**	-0.08**	-0.05**	-0.03*	0.04**	0.02	0.02	-0.00	0.03*	0.00	-0.08**	-0.03*	-0.14**	-0.21**	-0.00	0.00	-0.04**	0.05**	0.04**
46. Never Public Assistance	0.37**	0.34**	0.20**	0.11**	-0.15**	-0.05**	-0.14**	-0.02	-0.15**	-0.11**	0.26**	-0.01	0.55**	0.68**	-0.06**	0.02+	0.07**	-0.04**	-0.04**
47. Maternal Distress	-0.16**	-0.12**	-0.15**	-0.11**	0.13**	0.04*	0.09**	0.09**	0.14**	0.08**	-0.13**	0.02	-0.19**	-0.26**	0.08**	-0.01	-0.01	0.00	0.02
48. Child Mental Skills	0.12**	0.10**	0.04**	0.04*	-0.04**	-0.24**	-0.01	0.03*	-0.03*	-0.01	0.07**	0.04**	-0.01	0.01	-0.00	-0.02	-0.18**	0.10**	0.13*
49. Child Temperament	0.04**	0.03*	0.06**	0.05**	-0.02	-0.11**	-0.04**	-0.03	-0.08**	-0.03*	0.10**	-0.03*	0.03*	0.04**	0.03*	-0.04**	-0.09**	-0.01	-0.01
50. Maternal Work Hours	0.07**	0.07**	-0.03**	0.00	0.07**	-0.00	0.02+	0.08**	-0.01	0.02+	-0.12**	0.28**	0.11**	0.14**	-0.00	-0.00	-0.05**	0.06**	0.06**
51. Peer Exposure	0.17**	0.17**	0.02	0.04**	0.06**	-0.00	0.06**	0.12**	-0.01	0.03*	0.02	0.57**	0.19**	0.21**	0.01	0.00	0.03*	0.07**	0.10**

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$

	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
21. Child is Black	-0.34**	1.00															
22. Child is Hispanic	-0.42**	-0.21**	1.00														
23. Child is Asian/Pacific Islander	-0.36**	-0.18*	-0.22**	1.00													
24. Child is Multiracial	-0.25**	-0.13**	-0.15**	-0.13**	1.00												
25. Child is Male	-0.01	-0.01	-0.00	0.03*	-0.00	1.00											
26. Household Income ($10k)	0.24**	-0.23**	-0.22**	0.14**	0.00	0.00	1.00										
27. Mother Less than High School	-0.18**	0.03*	0.26**	-0.03**	-0.05**	0.01	-0.31**	1.00									
28. Mother High School/GED	-0.08**	0.10**	0.07**	-0.07**	-0.01	-0.02	-0.29**	-0.23**	1.00								
29. Mother Some College	0.06**	0.04*	-0.05**	-0.09**	0.03*	0.01	-0.06**	-0.27**	-0.39**	1.00							
30. Mother College+	0.15**	-0.16**	-0.21**	0.19*	0.01	0.00	0.57**	-0.26**	-0.37**	-0.44**	1.00						
31. Maternal Age	0.14**	-0.16**	-0.12**	0.10**	-0.01	0.01	0.41**	-0.16**	-0.18**	-0.03*	0.33**	1.00					
32. Non-English Household	-0.40**	-0.19**	0.37**	0.42**	-0.14**	0.02	-0.04**	0.22**	-0.03*	-0.16**	0.03*	0.05**	1.00				
33. Immigrant Household	-0.42**	-0.18**	0.30**	0.43**	-0.04**	0.00	0.07**	0.14**	-0.07**	-0.15**	0.11**	0.11**	0.75**	1.00			
34. Mother Always Married	0.24**	-0.33**	-0.12**	0.15**	-0.03*	-0.00	0.45**	-0.20**	-0.21**	-0.01	0.36**	0.42**	0.12**	0.18**	1.00		
35. Mother Sometimes Married	-0.00	0.04**	0.03*	-0.08**	0.02	-0.01	-0.14**	0.04**	0.06**	0.05**	-0.14**	-0.13**	-0.08**	-0.08**	-0.46**	1.00	
36. Mother Never Married	-0.27**	0.33**	0.11**	-0.11**	0.02	0.01	-0.40**	0.19**	0.19**	-0.02+	-0.30**	-0.38**	-0.08**	-0.15**	-0.78**	-0.19**	1.00
37. Minors in Household	0.00	0.08**	0.04**	-0.09**	-0.04**	-0.01	-0.12**	0.14**	0.04**	0.01	-0.15**	0.10**	-0.07**	-0.08**	-0.01	0.01	0.01
38. Child Always Private Insurance	0.26**	-0.20**	-0.22**	0.09**	-0.02+	0.01	0.63**	-0.28**	-0.25**	-0.01	0.46**	0.38**	-0.04**	0.06**	0.47**	-0.16**	-0.41**
39. Child Always Public Insurance	-0.24**	0.21**	0.15**	-0.06**	0.00	-0.02	-0.51**	0.24**	0.23**	-0.03*	-0.37**	-0.28**	0.02	-0.07**	-0.42**	0.10**	0.40**
40. Child Unstable Health Insurance	-0.04**	-0.01	0.09**	-0.05**	0.03*	0.01	-0.19**	0.06**	0.05**	0.04**	-0.13**	-0.13**	0.03*	0.01	-0.09**	0.08**	0.05**
41. Mother Always Employed	0.04**	-0.00	-0.08**	0.01	0.03*	0.00	0.23**	-0.18**	-0.06**	0.05**	0.14**	0.12**	-0.09**	-0.05**	0.04**	0.02	-0.06**
42. Mother Sometimes Employed	-0.05**	0.08**	0.04**	-0.04**	-0.03*	-0.00	-0.18**	0.02	0.08**	0.02	-0.11**	-0.13**	0.00	-0.02	-0.11**	0.06**	0.09**
43. Mother Never Employed	0.00	-0.09**	0.05**	0.03*	-0.00	0.00	-0.05**	0.18**	-0.02	-0.08**	-0.03*	0.01	0.10**	0.07**	0.08**	-0.08**	-0.03*
44. Always Public Assistance	-0.24**	0.25**	0.16**	-0.10**	0.00	-0.01	-0.54**	0.30**	0.22**	-0.05**	-0.38**	-0.29**	0.02	-0.07**	-0.44**	0.09**	0.42**
45. Sometimes Public Assistance	-0.09**	0.02	0.10**	-0.02	0.01	-0.00	-0.20**	0.00	0.09**	0.07**	-0.17**	-0.14**	0.05**	0.03*	-0.10**	0.10**	0.04**
46. Never Public Assistance	0.30***	-0.25**	-0.24**	0.11**	-0.01	0.01	0.68**	-0.29**	-0.29**	-0.02	0.50**	0.39**	-0.06**	0.04**	0.49**	-0.17**	-0.43**
47. Maternal Distress	-0.10**	0.12**	0.01	-0.00	0.01	0.01	-0.27**	0.10**	0.10**	0.03+	-0.19**	-0.13**	-0.05**	-0.08**	-0.23**	0.06**	0.21**
48. Child Mental Skills	-0.04**	-0.04**	0.00	0.05**	0.04**	-0.03*	-0.00	-0.02	0.02+	0.00	-0.01	-0.05**	-0.02	-0.01	-0.02+	0.04**	-0.00
49. Child Temperament	0.08**	-0.05**	-0.01	-0.04**	0.00	-0.05**	0.03*	-0.06**	-0.02	0.05**	0.01	0.00	-0.04**	-0.03*	0.03*	-0.01	-0.02+
50. Maternal Work Hours	-0.04**	0.06**	-0.02+	0.03+	0.01	0.00	0.10**	-0.16**	0.00	0.07**	0.05**	0.02+	-0.05**	-0.03+	-0.08**	0.08**	0.03*
51. Peer Exposure	-0.00	0.10**	-0.11**	0.01	0.01	-0.00	0.17**	-0.11**	-0.04**	-0.00	0.12**	0.03*	-0.09**	-0.08**	-0.06**	0.03*	0.04**

	37	38	39	40	41	42	43	44	45	46	47	48	49	50
38. Child Always Private Insurance	-0.11**	1.00												
39. Child Always Public Insurance	0.11**	-0.69**	1.00											
40. Child Unstable Health Insurance	0.00	-0.44**	-0.35**	1.00										
41. Mother Always Employed	-0.14**	0.25**	-0.20**	-0.07**	1.00									
42. Mother Sometimes Employed	0.03*	-0.20*	0.13**	0.10**	-0.60**	1.00								
43. Mother Never Employed	0.12**	-0.05**	0.08**	-0.03*	-0.44**	-0.45**	1.00							
44. Always Public Assistance	0.19**	-0.55**	0.55**	0.03*	-0.22**	0.15**	0.07**	1.00						
45. Sometimes Public Assistance	-0.03*	-0.20**	0.04**	0.21**	0.01	0.05**	-0.06**	-0.39**	1.00					
46. Never Public Assistance	-0.15**	0.70*	-0.56**	-0.21**	0.20**	-0.18**	-0.02	-0.61**	-0.49**	1.00				
47. Maternal Distress	0.03*	-0.24**	0.18**	0.08**	-0.11**	0.09**	0.02	0.24**	0.03*	-0.25**	1.00			
48. Child Mental Skills	-0.07**	-0.03*	0.01	0.02+	0.04**	-0.01	-0.04**	-0.01	0.04**	-0.02+	-0.02	1.00		
49. Child Temperament	-0.07**	0.03*	-0.03**	0.00	0.03*	-0.01	-0.02	-0.04**	0.01	0.03*	-0.08**	0.29**	1.00	
50. Maternal Work Hours	-0.12**	0.09**	-0.09**	-0.00	0.61**	-0.04**	-0.63**	-0.04**	-0.63**	-0.11**	-0.03+	0.02+	0.02	1.00
51. Peer Exposure	-0.09**	0.09**	-0.03*	-0.08**	0.26**	-0.05**	-0.24**	-0.05**	-0.24**	-0.05**	-0.02	-0.01	0.02+	0.16**

Descriptive Results

Table 3 reveals clear evidence of a socioeconomic status (SES) gradient across measures of children's health and development. No constant regressions tested for significant differences in the means and proportions of children's functioning and learning opportunities across levels of family income-to-needs, categorized as less than 100% poverty line, 100%-200%, 200%-300%, and greater than 300%, and levels of maternal education, categorized as less than high school, high school or GED, some college or professional school, and a college degree or higher. In each row, matched superscripts indicate significant differences between subgroups. There were distinct linear increases across the income and education strata in all of the school readiness indicators, excluding externalizing problems, which showed curvilinear decreases with income and education. There was also evidence of more modest and primarily linear decreases in most measures of children's health problems with increased income and education, although SES associations with health were less pronounced than with development. Diagnoses of acute conditions showed a different pattern, increasing with heightened income and education, perhaps in part reflecting the increased likelihood of having routine doctor visits and hence diagnoses of conditions such as ear and respiratory infections among more advantaged children (Newacheck et al., 1996). Finally, both home learning activities and hours in ECE increased with SES, with more consistent differences in home learning activities than in ECE hours.

Table 3. Socioeconomic Gradient in Health Indicators, School Readiness, and Early Learning Variables

	Family Income to Needs				Maternal Education			
	< 100%	100-200%	200-300%	300%+	Less than High School	High School/GED	Some College	College/Adv. Degree
School Readiness Skills								
Math Skills	34.75 (10.08) [abc]	38.92 (9.81) [ade]	41.60 (9.54) [bdf]	45.42 (9.07) [cef]	34.82 (10.28) [abc]	38.46 (9.71) [ade]	41.44 (9.87) [bdf]	46.45 (8.76) [cef]
Reading Skills	31.02 (13.09) [abc]	36.69 (13.91) [ade]	39.87 (14.30) [bdf]	44.74 (14.23) [cef]	31.14 (13.28) [abc]	36.12 (13.66) [ade]	39.59 (14.39) [bdf]	46.12 (14.35) [cef]
Learning Skills	3.67 (0.74) [abc]	3.88 (0.75) [ad]	3.96 (0.76) [be]	4.07 (0.68) [cde]	3.81 (0.74) [a]	3.83 (0.77) [b]	3.91 (0.73) [c]	4.12 (0.66) [abc]
Prosocial Behaviors	3.69 (0.66) [abc]	3.86 (0.66) [ad]	3.86 (0.66) [be]	3.96 (0.65) [cde]	3.81 (0.68) [a]	3.80 (0.66) [b]	3.85 (0.68) [c]	3.98 (0.62) [abc]
Externalizing Problems	2.11 (0.87) [abc]	1.93 (0.80) [a]	1.87 (0.82) [b]	1.86 (0.74) [c]	1.91 (0.83)	1.97 (0.83) [a]	1.98 (0.80) [b]	1.81 (0.73) [ab]
Child Health Indicators								
Neonatal Risks	0.10 [abc]	0.08 [ad]	0.07 [bde]	0.05 [ce]	0.08 [a]	0.08 [b]	0.07	0.06 [ab]
Asthma Diagnosis	0.22 [abc]	0.15 [ad]	0.14 [b]	0.10 [cd]	0.15 [a]	0.17 [b]	0.15 [c]	0.10 [abc]
Acute Conditions	3.30 (4.36) [a]	3.28 (3.97) [bc]	3.83 (4.70) [b]	3.77 (4.49) [ac]	3.14 (4.16) [ab]	3.28 (4.23) [c]	3.86 (4.54) [ac]	3.70 (4.40) [b]
Poor General Health	0.38 [abc]	0.30 [ade]	0.21 [bdf]	0.16 [cef]	0.40 [abc]	0.28 [ade]	0.22 [bdf]	0.16 [cef]
Hospitalization	0.19 [abc]	0.13 [ad]	0.11 [b]	0.10 [cd]	0.14	0.13	0.13	0.10
Early Learning Opportunities								
Home Learning Activities	-0.13 (0.34) [abc]	-0.04 (0.36) [ade]	0.04 (0.35) [bdf]	0.16 (0.34) [cef]	-0.17 (0.33) [abc]	-0.05 (0.34) [ade]	0.07 (0.35) [bdf]	0.18 (0.34) [cef]
Hours in ECE	0.06 (0.07) [a]	0.06 (0.07) [b]	0.06 (0.07) [c]	0.08 (0.08) [abc]	0.04 (0.06) [abc]	0.07 (0.08) [ad]	0.07 (0.08) [be]	0.08 (0.08) [cde]
N	1,250	1,500	950	2,200	800	1,450	1,850	1,750

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$ Superscript numerals represent significant differences between groups.

Aim 1. Direct Associations Between Health and School Readiness

The aim of the first set of models was to identify whether children's health conditions from birth through age 4 were directly associated with school readiness skills at age 5. Using linear regression analyses, these models controlled for a rich array of child, maternal, and family characteristics (Table 4) and revealed a consistent pattern of associations with children's pre-academic skills. Neonatal risks predicted 0.15 standard deviation units (SDs) lower math skills, 0.10 SDs lower reading skills, and 0.13 SDs lower learning skills. Similarly, parents' reports of children being in poor health were associated with 0.13 SDs lower math skills, 0.12 SDs lower reading skills, and 0.11 SDs lower learning skills. Hospitalization also predicted lower math and reading skills, on the order of 0.15 SDs and 0.10 SDs, respectively. Contrary to expectations, asthma diagnosis was related to 0.14 SDs higher learning skills. Acute conditions did not significantly predict any domains of children's school readiness skills, and no aspects of early childhood health were significantly associated with children's prosocial or externalizing behaviors. Effect sizes for the associations between health indicators and school readiness skills were nearly equivalent to effect sizes for increases in maternal education, such that the strength of the associations of neonatal risks, poor health, and hospitalization with children's pre-academic skills were similar in magnitude to the effect of having a mother with only a high school diploma or GED as compared to a mother with some college or professional training.

Table 4. Linear Regression Analyses Predicting School Readiness Skills

	Math Skills	Reading Skills	Learning Skills	Prosocial Behaviors	Externalizing Problems
	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)
Neonatal Risks	-1.62 (0.37)**	-1.48 (0.57)**	-0.10 (0.05)*	-0.06 (0.06)	0.04 (0.05)
Asthma Diagnosis	0.67 (0.51)	0.48 (0.60)	0.10 (0.05)*	0.04 (0.08)	-0.09 (0.06)
Acute Conditions	0.00 (0.04)	0.03 (0.06)	-0.01 (0.00)	0.00 (0.01)	0.01 (0.01)+
Poor Global Health	-1.37 (0.38)**	-1.85 (0.56)**	-0.08 (0.04)*	-0.07 (0.06)	0.07 (0.05)
Hospitalization	-1.56 (0.49)**	-1.59 (0.60)**	-0.08 (0.05)	0.03 (0.07)	0.05 (0.06)
ADHD Diagnosis	-6.36 (1.59)**	-6.06 (1.93)**	-0.57 (0.19)**	-0.55 (0.26)*	0.65 (0.24)**
Autism Diagnosis	0.29 (2.00)	3.65 (3.28)	-0.59 (0.19)**	-1.04 (0.33)**	0.52 (0.32)
Multiple Birth	-1.43 (0.45)**	-0.55 (0.63)**	-0.02 (0.05)	0.05 (0.08)	0.02 (0.05)
Kindergarten Exposure	1.21 (0.10)**	2.50 (0.15)**	-0.06 (0.01)**	-0.01 (0.01)	0.00 (0.01)
Child Age (months)	0.74 (0.05)**	0.89 (0.08)**	0.02 (0.01)**	0.01 (0.01)	-0.00 (0.01)
Child Race					
Black	-1.16 (0.53)*	1.33 (0.76)+	-0.50 (0.05)	0.06 (0.07)	0.02 (0.07)
Hispanic	-2.19 (0.54)**	-1.30 (0.73)+	0.00 (0.05)	0.04 (0.06)	-0.05 (0.06)
Asian/Pacific Islander	1.55 (0.57)**	4.47 (0.85)**	0.00 (0.05)	-0.09 (0.07)	-0.10 (0.06)
Multiracial	-1.81 (0.77)*	-1.33 (1.08)	-0.06 (0.08)	-0.06 (0.10)	0.07 (0.08)
Child Gender (male)	-0.33 (0.28)	-1.61 (0.40)**	-0.29 (0.03)**	-0.35 (0.04)**	0.40 (0.03)**
Household Income ($10k)	0.34 (0.05)**	0.43 (0.08)**	0.01 (0.01)	0.02 (0.01)**	-0.01 (0.01)+
Maternal Education					
Less than HS	-3.53 (0.48)**	-4.63 (0.68)**	0.00 (0.06)	0.07 (0.08)	-0.10 (0.07)
High School/GED	-1.57 (0.35)**	-1.90 (0.52)**	-0.03 (0.03)	-0.00 (0.05)	-0.05 (0.04)
College Degree	1.64 (0.38)**	2.26 (0.61)**	0.09 (0.05)+	0.08 (0.06)	-0.05 (0.04)
Maternal Age	0.01 (0.03)	0.01 (0.04)	-0.01 (0.00)*	-0.01 (0.00)**	0.01 (0.00)*
Non-English Household	-0.58 (0.64)	-1.38 (0.94)	0.10 (0.06)+	0.13 (0.08)+	-0.09 (0.07)
Immigrant Household	0.40 (0.50)	0.83 (0.85)	-0.00 (0.05)	-0.10 (0.07)**	-0.03 (0.06)
Mother is Married					
Sometimes	-0.64 (0.50)	-1.61 (0.69)*	-0.11 (0.06)*	-0.13 (0.08)	0.15 (0.07)*
Never	-0.86 (0.42)*	-2.24 (0.62)**	-0.14 (0.05)**	-0.19 (0.07)**	0.11 (0.07)+
Minors in Household	-0.61 (0.15)**	-1.50 (0.21)**	0.00 (0.02)	-0.03 (0.02)	-0.05 (0.02)**
Child Health Insurance					
Always Public	-0.73 (0.56)	0.08 (0.77)	0.01 (0.06)	-0.04 (0.07)	0.08 (0.07)
Unstable Arrangement	-0.22 (0.45)	0.29 (0.72)	0.02 (0.06)	0.09 (0.08)	0.04 (0.06)
Maternal Employment					
Sometimes	-0.15 (0.38)	-0.83 (0.51)	-0.06 (0.03)+	-0.10 (0.04)*	0.01 (0.04)
Never	0.29 (0.39)	-0.13 (0.57)	0.04 (0.04)	0.00 (0.06)	-0.16 (0.04)**
Public Assistance					
Always	-1.65 (0.55)**	-2.51 (0.86)**	-0.15 (0.06)*	-0.01 (0.09)	0.12 (0.08)
Sometimes	-1.77 (0.48)**	-2.92 (0.70)**	-0.17 (0.06)**	-0.13 (0.08)+	0.10 (0.06)
Constant	-7.10 (3.07)*	-18.82 (4.76)**	3.56 (0.38)**	0.40 (0.47)	1.78 (0.42)**

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$

Aim 2. Indirect Associations Through Home Learning Activities and ECE

The next set of analyses investigated whether direct associations between children's physical health and school readiness could be explained by children's access to early learning opportunities. In order to test this proposition, path analyses were used to estimate a multiple mediator model in which children's health conditions predicted home learning activities and ECE participation, which in turn predicted school readiness skills (see conceptual model presented in Figure 1). These models included the same set of child and family covariates as those included in prior models to predict both mediators measured at Wave 3 and school readiness measured at Wave 4. As an exception, months of kindergarten exposure was included as a covariate to predict school readiness outcomes only at Wave 4 because it was measured after indicators of early learning contexts (Wave 3). Regarding model specification, path models were first tested without replicate weights, since the chi-square values and modification indices cannot be produced when the model employs replicate weights, and minor adjustments were made to the models according to the modification indices. After these adjustments, models were re-run including the replicate weights. All final weighted models were well fit to these data (Table 5), as indicated by values for the chi-square, RMSEA, CFI, TLI, and SRMR mostly within the acceptable ranges (Hu & Bentler, 1999).

Table 5. Fit Statistics for Path Analyses

	Math Skills	Reading Skills	Learning Skills	Prosocial Behaviors	Externalizing Problems
χ^2 (df)	10.41 (2)**	10.71 (2)**	10.09 (2)**	10.08 (2)**	10.12 (2)**
RMSEA [a]	0.03	0.03	0.03	0.03	0.03
RMSEA 90% CI	(0.01, 0.04)	(0.01, 0.04)	(0.01, 0.04)	(0.01, 0.04)	(0.01, 0.04)
CFI [b]	1.00	1.00	1.00	0.99	1.00
TLI [c]	0.86	0.85	0.74	0.72	0.74
SRMR [d]	0.00	0.00	0.00	0.00	0.00
R^2 for Outcome	0.39	0.41	0.13	0.08	0.15

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$

[a] RMSEA = Root Mean Square Error of Approximation

[b] CFI = Comparative Fit Index

[c] TLI = Tucker Lewis Index

[d] SRMR = Standardized Root Mean Square Residual

Results of the path models revealed limited evidence of mediation through early learning opportunities (Table 6; Figures 2a-2e), but results showed that these early learning mediators were significant predictors of some domains of children's school readiness skills. Each standard deviation increase in home learning activities was associated with a 0.26 SD increase in math skills, a 0.25 SD increase in reading and learning skills, and a 0.26 SD decrease in externalizing problems, where as each 10 hours in ECE predicted 0.04 SDs higher math skills, 0.06 SDs higher reading skills, and 0.06 SDs higher externalizing problems. Surprisingly, there was limited evidence that health conditions predicted the early learning mediators. Neonatal risks did not predict home learning or time in ECE, but continued to directly predict 0.15 SDs lower math skills, 0.09 SDs lower reading skills, and 0.14 SDs lower learning skills, after controlling for early learning opportunities. A similar pattern emerged with hospitalization, which did not predict home learning or time in ECE, though models controlling for these contexts continued to predict lower math and reading skills, on the order of 0.13 SDs and 0.09 SDs, respectively. These findings indicated that there were no indirect effects explaining associations between neonatal risks or hospitalization and school readiness skills.

Regarding children's asthma diagnosis, acute conditions, and poor health, there were some expected and some unexpected associations linking these health conditions to school readiness skills through early learning contexts. For example, each additional acute condition predicted 0.02 SDs higher ECE hours, which ran counter to hypotheses that health conditions would be associated with less time in ECE. Using bootstrap-based bias-corrected confidence intervals to test for indirect effects revealed significant positive indirect effects linking acute conditions to higher math, reading, and externalizing problems through more time in ECE (Table 7), despite the fact that no direct effects between acute conditions and school readiness skills emerged. This surprising finding was further explored, with additional analyses detailed in Appendix B, which suggested that associations between acute conditions and time in ECE were confounded with children's exposure to peers in non-parental care settings (see page 127 for details).

In addition, asthma diagnosis predicted 0.05 SDs greater home learning activities but did not predict ECE participation. Indirect effects from asthma through the home learning environment did not reach the statistically significant threshold of $p < .05$, and the positive main effect relating asthma diagnosis to higher learning skills held even after controlling for early learning contexts. Only poor global health functioned as hypothesized, with parents' reports of the child's poor health predicting 0.06 SDs lower home learning activities, which yielded negative indirect effects for associations between poor health and lower math, reading, and learning skills, and higher externalizing. In models testing for indirect effects of poor health through home learning activities, main effects from children's health problems to math and reading remained statistically significant, and only the coefficient for learning skills was reduced by 18% to a

marginally significant level with the addition of the early learning contexts mediators. These findings suggest that home learning was a more effective mediator of the association linking poor health with learning skills than with pre-academic skills, given that the direct effect was reduced modestly in size and statistical significance (Hayes, 2013). Furthermore, these models showed that, although there were no main effects linking children's health conditions to externalizing problems, associations functioned indirectly to link poor health with externalizing problems through home learning. This inconsistent mediation may be evidence of a suppression effect in which unmeasured factors or processes reduce the appearance of main effects (MacKinnon et al., 2007). Hence, there are likely other mechanisms that explain these associations, beyond children's experiences in their early learning contexts.

In short, findings suggest that negative associations between neonatal risks and children's lower pre-academic and learning skills were not explained by their access to or participation in early learning contexts. Similarly, associations between hospitalization and lower pre-academic skills also functioned directly. Even though asthma diagnosis predicted greater home learning activities, indirect pathways linking asthma diagnosis with school readiness skills did not reach a statistically significant level. Poor health, on the other hand, was related to children's school readiness skills in part through reduced home learning activities, and results suggest that acute conditions were indirectly related to school readiness through increased time in ECE, but supplementary analyses conducted in Appendix B raise concerns about these findings. Furthermore, the magnitude of indirect effects was extremely small, drawing attention to issues regarding the practical significance of these results.

Table 6. Path Analysis Results Predicting School Readiness Skills

	Predicting Mediators		Predicting School Readiness Skills				
	Home Learning	Time in ECE	Math Skills	Reading Skills	Learning Skills	Prosocial Behaviors	Externalizing Problems
	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)
Neonatal Risks	0.01 (0.00)	-0.03 (0.06)	-1.60 (0.37)**	-1.44 (0.57)*	-0.10 (0.05)*	-0.04 (0.04)	0.04 (0.05)
Asthma Diagnosis	0.05 (0.02)*	0.14 (0.10)	0.33 (0.53)	0.01 (0.61)	0.10 (0.04)*	0.03 (0.06)	-0.08 (0.06)
Acute Conditions	0.00 (0.00)	0.03 (0.01)**	-0.00 (0.04)	0.01 (0.06)	-0.01 (0.00)	0.00 (0.00)	0.01 (0.01)+
Poor Global Health	-0.06 (0.02)*	-0.02 (0.06)	-1.26 (0.38)**	-1.67 (0.55)**	-0.07 (0.04)+	-0.04 (0.04)	0.05 (0.05)
Hospitalization	-0.02 (0.02)	-0.02 (0.09)	-1.45 (0.49)**	-1.40 (0.62)*	-0.07 (0.05)	0.02 (0.05)	0.04 (0.06)
Home Learning Activities	-	-	2.78 (0.40)**	3.90 (0.56)**	0.19 (0.04)**	0.06 (0.04)+	-0.21 (0.04)**
Time in ECE	-	-	0.41 (0.09)**	0.90 (0.14)**	-0.02 (0.01)+	0.00 (0.01)	0.04 (0.01)**
ADHD Diagnosis	-0.15 (0.07)*	-0.15 (0.38)	-6.23 (1.62)**	-5.75 (1.91)*	-0.54 (0.18)**	-0.36 (0.18)*	0.61 (0.23)**
Autism Diagnosis	0.04 (0.0)	0.36 (0.32)	0.31 (1.97)	3.52 (3.17)	-0.60 (0.20)**	-0.72 (0.23)**	0.52 (0.32)
Multiple Birth	0.02 (0.02)	0.14 (0.08)+	-1.68 (0.45)**	-0.94 (0.63)	-0.02 (0.05)	0.03 (0.05)	0.02 (0.05)
Kindergarten Exposure	-	-	1.68 (0.09)**	3.05 (0.13)**	-0.04 (0.01)**	0.00 (0.01)	-0.01 (0.01)
Child Age (months)	-0.00 (0.00)**	0.04 (0.01)**	0.44 (0.04)**	0.49 (0.05)**	0.00 (0.00)**	-0.00 (0.00)	-0.00 (0.01)
Child Race							
Black	-0.10 (0.03)**	0.79 (0.11)**	-1.34 (0.51)**	0.84 (0.74)	-0.30 (0.05)	0.04 (0.05)	-0.02 (0.07)
Hispanic	-0.07 (0.03)**	0.03 (0.13)	-2.34 (0.53)**	-1.45 (0.73)*	0.00 (0.05)	0.03 (0.04)	-0.06 (0.05)
Asian/Pacific Islander	-0.03 (0.03)	0.22 (0.12)+	1.81 (0.58)*	3.95 (0.86)**	0.00 (0.05)	-0.07 (0.05)	-0.10 (0.06)+
Multiracial	-0.01 (0.03)	-0.02 (0.15)	-1.73 (0.80)*	-1.25 (1.08)	-0.06 (0.08)	-0.04 (0.07)	0.07 (0.08)
Child Gender (male)	-0.05 (0.01)**	-0.04 (0.06)	-0.14 (0.29)	-1.35 (0.42)**	-0.28 (0.03)**	-0.24 (0.03)**	0.39 (0.03)**
Household Income ($10k)	0.00 (0.00)	0.05 (0.01)**	0.30 (0.05)**	0.35 (0.08)**	0.01 (0.01)	0.01 (0.01)**	-0.01 (0.01)*
Maternal Education							
Less than HS	-0.19 (0.02)**	-0.26 (0.11)*	-2.99 (0.48)**	-3.78 (0.66)**	0.03 (0.06)	0.06 (0.06)	-0.12 (0.07)+
High School/GED	-0.11 (0.02)**	0.03 (0.09	-1.21 (0.35)**	-1.40 (0.55)*	-0.00 (0.03)	0.01 (0.03)	-0.08 (0.04)+
College Degree	-0.10 (0.02)**	0.27 (0.07)**	1.40 (0.39)**	1.80 (0.63)**	0.08 (0.05)+	0.05 (0.04)	-0.04 (0.05)
Maternal Age	0.00 (0.00)	0.00 (0.01)	0.01 (0.03)	0.00 (0.03)	-0.01 (0.00)*	-0.01 (0.00)*	0.01 (0.00)+
Non-English Household	-0.12 (0.03)**	0.03 (0.11)	-0.39 (0.62)	-1.09 (0.93)	0.13 (0.06)*	0.10 (0.05)+	-0.12 (0.07)+
Immigrant Household	0.01 (0.03)	0.05 (0.11)	0.26 (0.49)	0.65 (0.84)	0.00 (0.05)	-0.07 (0.05)**	-0.03 (0.06)

Mother is Married							
Sometimes	0.00 (0.03)	0.06 (0.10)	-0.71 (0.51)	-1.73 (0.67)*	-0.11 (0.06)+	-0.08 (0.05)	0.14 (0.07)*
Never	-0.01 (0.03)	0.34 (0.08)**	-1.03 (0.44)*	-2.57 (0.60)**	-0.13 (0.05)*	-0.12 (0.05)**	0.09 (0.07)+
Minors in Household	-0.03 (0.01)**	-0.15 (0.03)**	-0.43 (0.14)**	-1.22 (0.21)**	0.00 (0.02)	-0.02 (0.02)	-0.05 (0.02)**
Child Health Insurance							
Always Public	-0.02 (0.02)	0.32 (0.10)**	-0.80 (0.56)	-0.13 (0.77)	0.02 (0.06)	-0.03 (0.05)	0.06 (0.07)
Unstable Arrangement	-0.02 (0.03)	0.05 (0.10)	-0.33 (0.46)	0.17 (0.70)	0.02 (0.06)	0.06 (0.05)	0.03 (0.06)
Maternal Employment							
Sometimes	0.09 (0.02)**	-0.47 (0.07)**	-0.30 (0.36)	-0.85 (0.50)+	-0.08 (0.03)*	-0.07 (0.03)*	0.05 (0.04)
Never	0.16 (0.02)**	-0.74 (0.06)**	0.21 (0.42)	-0.00 (0.61)	-0.00 (0.04)	-0.01 (0.04)	-0.10 (0.04)*
Public Assistance							
Always	-0.08 (0.03)**	0.31 (0.12)*	-1.75 (0.54)**	-2.74 (0.84)**	-0.13 (0.06)*	0.00 (0.06)	0.10 (0.08)
Sometimes	-0.08 (0.02)**	0.17 (0.10)	-1.69 (0.47)**	-2.82 (0.69)**	-0.14 (0.06)*	-0.08 (0.05)	0.07 (0.06)
Constant	0.35 (0.08)**	-0.99 (0.38)*	16.47 (1.97)*	10.40 (3.06)**	4.31 (0.25)**	4.29 (0.20)**	1.66 (0.28)**

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$

Figures 2a-2e. Standardized Path Analysis Results Predicting School Readiness Skills

Figure 2a. Math Skills

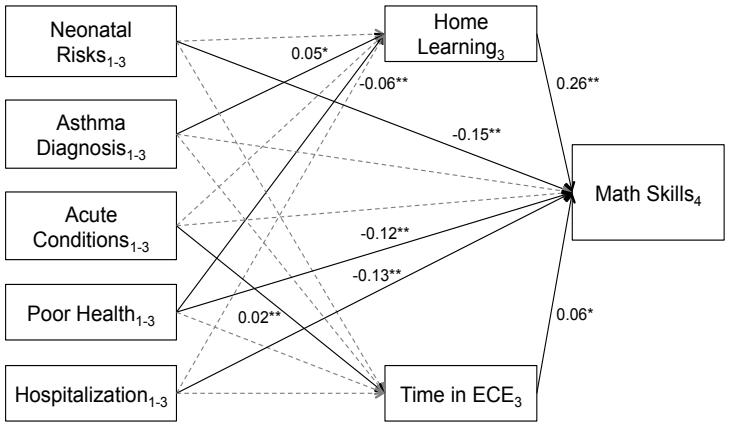


Figure 2b. Reading Skills

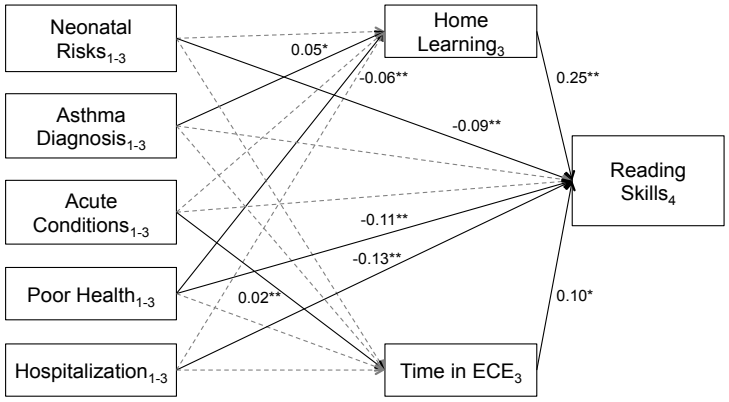


Figure 2c. Learning Skills

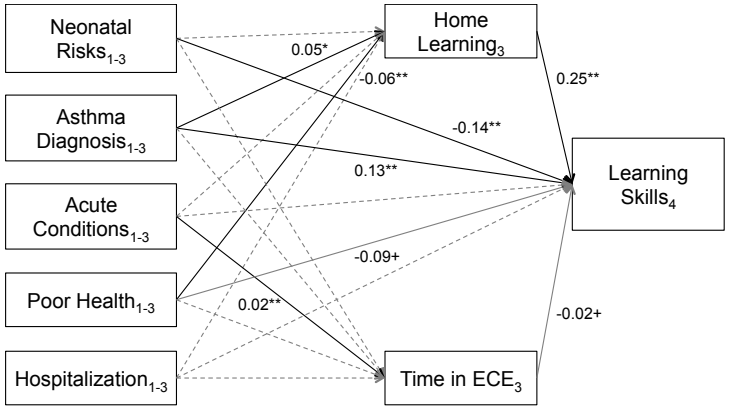


Figure 2d. Prosocial Behaviors

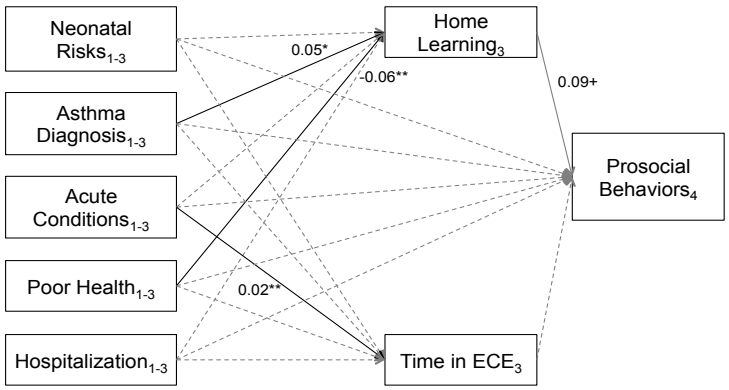
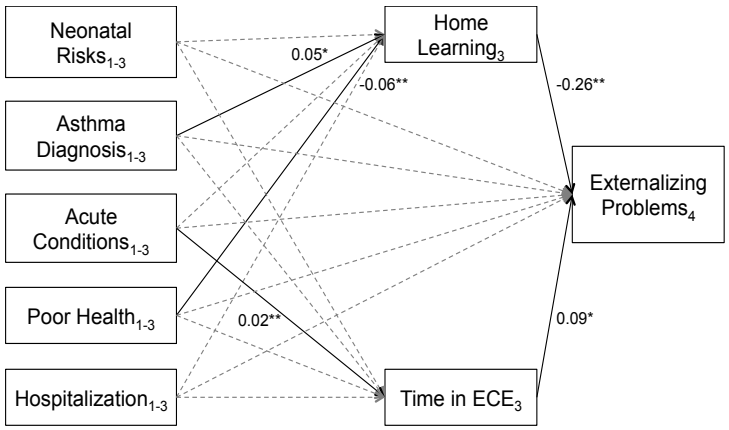


Figure 2e. Externalizing Problems



Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$ Significant paths depicted in solid black lines. Marginally significant paths depicted in solid grey lines. Non-significant paths depicted in grey dashed line. Coefficients for non-significant paths not shown. Covariates predicted all endogenous variables.

Table 7. Indirect Effects Linking Health and School Readiness Skills

	Math Skills		Reading Skills		Learning Skills		Prosocial Behaviors		Externalizing Problems	
	ab (SE)	95% CI	*ab* (SE)	95% CI	*ab* (SE)	95% CI	*ab* (SE)	95% CI	*ab* (SE)	95% CI
Neonatal Risk										
→ Home Learning	0.02 (0.05)	(0.01, 0.03)	0.02 (0.07)	(0.01, 0.04)	0.00 (0.00)	(0.00, 0.00)	0.00 (0.00)	(0.00, 0.00)	-0.00 (0.00)	(-0.00, -0.00)
→ ECE	-0.01 (0.03)	(-0.02, -0.01)	-0.02 (0.06)	(-0.04, -0.01)	0.00 (0.00)	(0.00, 0.00)	0.00 (0.00)	(0.00, 0.00)	-0.00 (0.00)	(-0.00, -0.00)
Asthma										
→ Home Learning	0.13 (0.07)+	(0.12, 0.15)	0.19 (0.10)+	(0.16, 0.21)	0.01 (0.01)	(0.01, 0.01)	0.00 (0.01)	(0.01, 0.01)	-0.01 (0.01)+	(-0.01, -0.01)
→ ECE	0.06 (0.04)	(0.05, 0.07)	0.13 (0.09)	(0.11, 0.14)	-0.00 (0.02)	(-0.00, -0.00)	0.00 (0.02)	(0.00, 0.00)	0.01 (0.00)	(0.01, 0.01)
Acute Conditions										
→ Home Learning	0.00 (0.01)	(0.00, 0.01)	0.01 (0.01)	(0.01, 0.01)	0.00 (0.00)	(0.00, 0.00)	0.00 (0.00)	(0.00, 0.00)	0.00 (0.00)	(0.00, 0.00)
→ ECE	0.01 (0.00)**	(0.01, 0.01)	0.02 (0.01)**	(0.02, 0.03)	0.00 (0.00)	(-0.00, 0.00)	0.00 (0.00)	(0.00, 0.00)	0.00 (0.00)	(0.00, 0.00)
Poor Health										
→ Home Learning	-0.17 (0.05)**	(-0.19, -0.17)	-0.24 (0.08)**	(-0.27, -0.23)	-0.01 (0.00)**	(-0.01, -0.01)	-0.01 (0.00)**	(-0.00, -0.00)	0.01 (0.00)**	(0.01, 0.01)
→ ECE	-0.01 (0.03)	(-0.02, -0.01)	-0.02 (0.06)	(-0.04, -0.01)	0.00 (0.00)	(0.00, 0.00)	0.00 (0.00)	(0.00, 0.00)	-0.00 (0.00)	(-0.00, 0.00)
Hospitalization										
→ Home Learning	-0.07 (0.06)	(-0.07, -0.04)	-0.09 (0.08)	(-0.10, -0.06)	0.00 (0.00)	(-0.01, -0.00)	-0.01 (0.00)	(-0.00, -0.00)	0.01 (0.00)	(0.00, 0.01)
→ ECE	-0.01 (0.04)	(-0.02, 0.00)	-0.01 (0.08)	(-0.04, -0.00)	0.00 (0.00)	(0.00, 0.00)	0.00 (0.00)	(0.00, 0.00)	-0.00 (0.00)	(-0.00, 0.00)

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$

Aim 3. Interactions Between Health and Early Learning Opportunities Predicting School Readiness

In the first two sets of models, analyses tested for main associations between health and school readiness skills and for indirect associations connecting health and school readiness skills through early learning pathways. Alternatively, the associations between and health and school readiness might be moderated by children's abilities to engage in or benefit from early learning opportunities in the home or in ECE. If significant, interactions between children's health and early learning opportunities might reveal that either early learning contexts are most beneficial for healthy children who can fully engage in learning opportunities, suggesting a potentiating effect, or interactions might reveal that children with health problems benefit the most, suggesting a compensatory role. In these models, interactions terms between each health indicator and each early learning variable were added to the main effects model. All variables in interaction models had variance inflation factors (VIFs) below 4, signifying no issues with multicollinearity.

Results are presented in Table 8. Across all of the interactions, 7 of 50 were significant, which was above the rate of chance, with a consistent pattern of significant interactions emerging between hospitalization and ECE contexts. Across the models, hospitalization interacted with ECE to predict math and learning skills, prosocial behaviors, and externalizing problems. These results show a compensatory effect, with ECE hours appearing most protective for children who had been hospitalized, and this pattern was replicated for reading skills at a level of marginal significance. As shown in Figure 3, representing results for the interaction between hospitalization and ECE hours

predicting children's reading skills, the negative relations between hospitalization and math skills were tempered by greater exposure to ECE. That is, hospitalized children who spent a below average amount of time in ECE displayed lower math skills than their non-hospitalized peers spending equally limited amounts of time in ECE. As the amount of time children spent in ECE increased, hospitalized children displayed math skills that were nearly equivalent to their non-hospitalized peers. Again, these models suggest that ECE hours were protective for children who had been hospitalized, but neutrally or negatively associated with behavioral functioning among children who were not hospitalized. As an exemplar, Figure 4 presents results for children's prosocial skills, showing that more time in ECE accrued greater benefits for prosocial skills to children who were hospitalized, in comparison to non-hospitalized peers, whose prosocial skills decreased slightly as time in ECE increased.

Interactions between home learning activities and children's health were somewhat less consistent. One significant interaction emerged between home learning and hospitalizations predicting children's reading skills, showing the same pattern as the ECE interactions, with the positive connection between home learning activities and children's reading skills strengthened among children who had been hospitalized compared to their non-hospitalized peers. In addition, significant interactions emerged between children's asthma diagnosis and home learning activities in predicting children's learning and prosocial behaviors. Here, results suggest a potentiating effect, as the benefits of home learning activities were only accrued to children who were not diagnosed with asthma (Figure 5).

Table 8. Interactions Between Health and Early Learning Contexts Predicting School Readiness

	Math Skills	Reading Skills	Learning Skills	Prosocial Behaviors	Externalizing Problems
	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)
Neonatal Risk	-1.65 (0.37)**	-1.50 (0.57)**	-0.10 (0.05)*	-0.04 (0.04)	0.04 (0.05)
Asthma Diagnosis	0.32 (0.54)	0.05 (0.61)	0.09 (0.05)+	0.01 (0.06)	-0.07 (0.06)
Acute Conditions	0.00 (0.04)	0.01 (0.06)	-0.01 (0.00)	0.00 (0.00)	0.01 (0.05)
Poor Health	-1.24 (0.39)**	-1.65 (0.56)**	-0.07 (0.04)	-0.05 (0.04)	0.05 (0.05)
Hospitalization	-1.43 (0.49)**	-1.47 (0.62)*	-0.06 (0.05)	0.02 (0.05)	0.03 (0.06)
Home Learning	2.57 (0.42)**	3.90 (0.68)**	0.19 (0.04)**	0.08 (0.04)+	-0.19 (0.04)**
Home X Neonatal	-1.22 (0.91)	-1.51 (1.22)	0.03 (0.11)	0.09 (0.09)	0.12 (0.11)
Home X Asthma	-0.32 (0.95)	1.64 (1.48)	-0.25 (0.13)*	-0.29 (0.12)*	0.21 (0.15)
Home X Acute	-0.14 (0.09)	-0.13 (0.13)	0.01 (0.01)	0.01 (0.01)	-0.02 (0.01)+
Home X Poor Health	0.11 (0.78)	0.09 (1.31)	-0.02 (0.10)	-0.03 (0.08)	-0.09 (0.11)
Home X Hosp.	2.53 (1.19)**	-1.24 (1.70)	0.29 (0.15)+	0.21 (0.12)+	-0.30 (0.17)+
Time in ECE	0.33 (0.10)**	0.87 (0.19)**	-0.03 (0.01)*	-0.01 (0.01)	0.06 (0.01)**
ECE X Neonatal	-0.11 (0.24)	-0.27 (0.30)	-0.01 (0.03)	-0.02 (0.02)	0.01 (0.03)
ECE X Asthma	-0.12 (0.22)	-0.42 (0.29)	-0.02 (0.03)	-0.01 (0.03)	0.00 (0.03)
ECE X Acute	0.00 (0.02)	-0.01 (0.03)	0.00 (0.00)	0.00 (0.00)	0.01 (0.00)+
ECE X Poor Health	0.03 (0.22)	0.08 (0.28)	0.02 (0.02)	0.00 (0.02)	-0.02 (0.02)
ECE X Hosp.	0.68 (0.30)*	0.79 (0.43)+	0.07 (0.03)*	0.07 (0.03)*	-0.11 (0.03)**
ADHD Diagnosis	-6.05 (1.61)**	-5.77 (1.96)**	-0.51 (0.18)**	-0.33 (0.18)+	0.56 (0.23)*
Autism Diagnosis	0.09 (1.94)	3.38 (3.15)	-0.60 (0.20)**	-0.71 (0.22)**	0.53 (0.29)+
Multiple Birth	-1.59 (0.44)**	-0.83 (0.64)	-0.03 (0.05)	0.02 (0.05)	0.02 (0.05)
Kindergarten Exposure	1.67 (0.09)**	3.05 (0.13)**	-0.04 (0.01)**	0.00 (0.01)	-0.01 (0.01)
Child Age (months)	0.43 (0.04)**	0.49 (0.05)**	0.00 (0.00)	-0.00 (0.00)	-0.00 (0.01)
Child Race					
Black	-1.28 (0.52)*	0.93 (0.76)	-0.03 (0.05)	0.03 (0.05)	-0.01 (0.07)
Hispanic	-2.31 (0.53)**	-1.42 (0.73)+	-0.00 (0.05)	0.02 (0.04)	-0.05 (0.06)
Asian/Pacific Islander	1.19 (0.58)*	3.95 (0.85)**	0.00 (0.05)	-0.06 (0.05)	-0.10 (0.06)+
Multiracial	-1.76 (0.79)*	-1.24 (1.08)	-0.06 (0.08)	-0.04 (0.07)	0.07 (0.08)
Child Gender (male)	-0.12 (0.29)	-1.33 (0.42)**	-0.29 (0.03)**	-0.24 (0.03)**	0.39 (0.03)**
Household Income	0.30 (0.06)**	0.36 (0.08)**	0.01 (0.01)	0.01 (0.01)**	-0.01 (0.01)*
Maternal Education					
Less than HS	-2.97 (0.48)**	-3.74 (0.66)**	0.02 (0.06)	0.05 (0.05)	-0.11 (0.06)+
High School/GED	-1.22 (0.35)**	-1.39 (0.55)*	-0.00 (0.03)	0.00 (0.03)	-0.08 (0.04)+
College Degree	1.41 (0.40)**	1.82 (0.63)**	0.08 (0.05)+	0.05 (0.04)	-0.05 (0.04)
Maternal Age	0.00 (0.03)	-0.00 (0.03)	-0.01 (0.00)*	-0.01 (0.00)*	0.01 (0.00)+
Non-English Household	-0.31 (0.63)	-1.06 (0.93)	0.13 (0.06)*	0.10 (0.05)+	-0.13 (0.07)*
Immigrant Household	0.21 (0.49)	0.64 (0.83)	-0.01 (0.05)	-0.08 (0.05)	-0.02 (0.06)
Mother is Married					
Sometimes	-0.69 (0.51)	-1.74 (0.68)*	-0.10 (0.06)+	-0.07 (0.05)	0.13 (0.07)+
Never	-1.00 (0.44)*	-2.57 (0.60)**	-0.12 (0.05)*	-0.12 (0.05)**	0.09 (0.07)
Minors in Household	-0.44 (0.14)**	-1.23 (0.21)**	0.00 (0.02)	-0.02 (0.02)	-0.05 (0.02)**
Child Health Insurance					
Always Public	-0.83 (0.56)	-0.15 (0.77)	0.02 (0.06)	-0.03 (0.05)	0.06 (0.06)
Unstable Arrangement	-0.35 (0.45)	0.14 (0.69)	0.02 (0.06)	0.06 (0.05)	0.03 (0.06)
Maternal Employment					
Sometimes	-0.27 (0.36)	-0.85 (0.51)+	-0.08 (0.03)**	-0.07 (0.03)*	0.04 (0.04)
Never	0.22 (0.41)	-0.02 (0.61)	-0.00 (0.04)	-0.01 (0.04)	-0.10 (0.04)*
Public Assistance					
Always	-1.78 (0.53)**	-2.76 (0.83)**	-0.14 (0.06)*	0.00 (0.05)	0.10 (0.07)
Sometimes	-1.68 (0.47)**	-2.80 (0.69)**	-0.15 (0.06)*	-0.08 (0.06)	0.07 (0.06)
Constant	44.97 (0.44)**	44.42 (0.74)**	4.19 (0.05)**	4.04 0.05**	1.70 (0.05)**

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$

Figure 3. Interaction Between ECE and Hospitalization Predicting Math

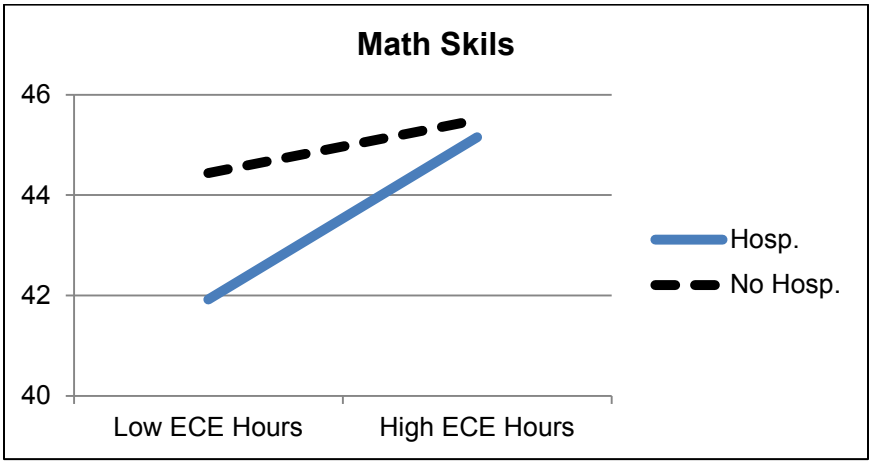


Figure 4. Interaction Between ECE and Hospitalization Predicting Prosocial

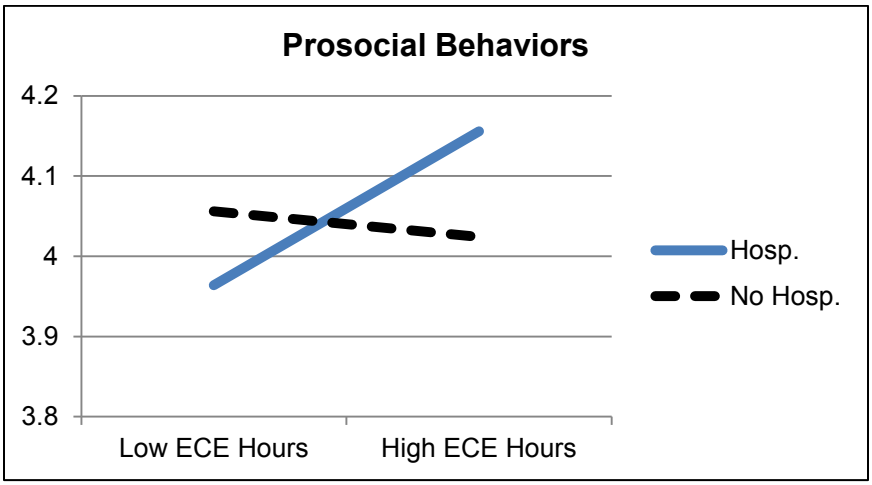
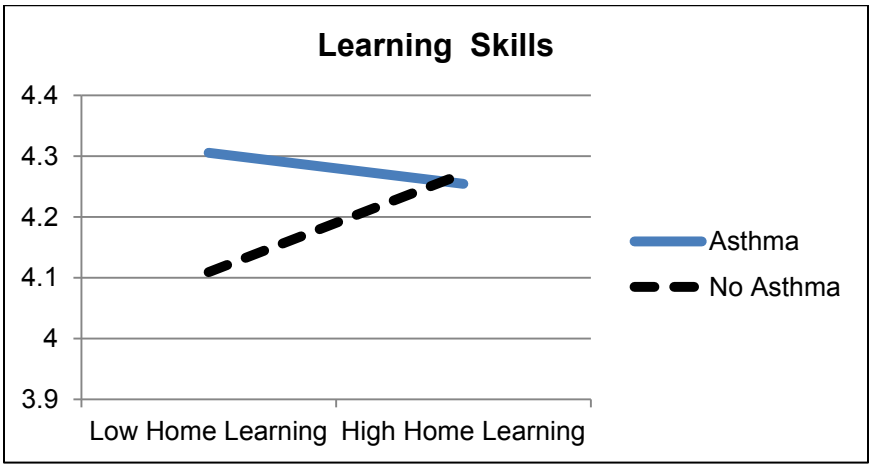


Figure 5. Interaction Between Home Learning and Asthma Predicting Learning



Aim 4. Associations Between Health and School Readiness Skills Moderated by Family SES

The first three sets of models examined main, indirect, and interacted associations connecting children's physical health and school readiness skills. Given the important role of family socioeconomic resources, such as family income-to-needs and maternal education, the next three sets of models examined whether the associations identified in the prior set of models functioned differently for children in more versus less socioeconomically advantaged families. Interactions with family income-to-needs and maternal education were conducted individually across the set of three models due to concerns about collinearity of interaction terms with income and education in the same models. Across both sets of models, the rate of significant interactions was slightly above the rate expected by chance, with 11 of 120 significant income interactions and 10 of 120 significant maternal education interactions.

Moderation of main effects by family SES. The first set of moderation models tested whether the main associations between children's health and school readiness varied across the SES spectrum by including interactions between the mean-centered continuous measure of income and each of the health variables (acute conditions, as a continuous variable, was also centered). The first panel of Table 9 shows limited evidence that family resources moderated associations between children's physical health and school readiness skills. Of 25 interactions tested between family income and individual health variables, only 2 were statistically significant, just above the level expected simply by chance. A significant interaction between family income and poor health predicted children's math skills, and examination of this interaction revealed that

higher income protected children from the negative association between poor health and lower math skills. A significant interaction also emerged between income and hospitalization predicting externalizing behaviors, again revealing a compensatory effect of income, such that low-income children who were hospitalized exhibited higher externalizing problems than their non-hospitalized peers, but among high-income families, hospitalized children displayed lower externalizing problems. These findings show an emerging pattern but, overall, these models contain limited evidence that low family income exacerbates associations between children's health and school readiness skills, considering that the vast majority of interactions were nonsignificant.

A second set of models examined interactions between children's health and the continuous measure of maternal education, with results presented in the second panel of Table 9. Across these models, 3 of 25 interactions were statistically significant, with interactions between education and acute conditions predicting math skills and interactions between education and hospitalization predicting reading skills and externalizing problems. Further probing of these interaction effects revealed no clear pattern of associations, with maternal education functioning in ways that both attenuate and exacerbate associations between children's health and school readiness skills.

Table 9. Interactions Between Health and Family SES Predicting School Readiness Skills

	Math Skills	Reading Skills	Learning Skills	Prosocial Behaviors	Externalizing Problems
	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)
Model 1: Interactions with Family Income					
Neonatal Risks	-1.68 (0.35)**	-1.53 (0.59)*	-0.10 (0.05)*	-0.04 (0.04)	0.04 (0.05)
Asthma Diagnosis	0.58 (0.51)	0.51 (0.64)	0.10 (0.05)*	0.02 (0.06)	-0.09 (0.06)
Acute Conditions	0.00 (0.04)	0.03 (0.06)	-0.01 (0.00)	0.00 (0.00)	0.01 (0.01)+
Poor Global Health	-1.20 (0.39)**	-1.74 (0.58)**	-0.08 (0.04)+	-0.05 (0.04)	0.06 (0.05)
Hospitalization	-1.52 (0.48)**	-1.59 (0.64)*	-0.08 (0.05)	0.02 (0.05)	0.05 (0.06)
Family Income to Needs	0.56 (0.10)**	0.80 (0.13)**	0.01 (0.01)	0.03 (0.01)**	-0.01 (0.01)
Neonatal Risk X Income	-0.10 (0.17)	-0.06 (0.23)	0.00 (0.02)	0.01 (0.02)	0.00 (0.02)
Asthma X Income	-0.26 (0.20)	0.05 (0.28)	-0.01 (0.02)	-0.01 (0.02)	0.00 (0.03)
Acute X Income	0.01 (0.02)	-0.01 (0.03)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Poor Health X Income	0.33 (0.15)*	0.16 (0.23)	0.01 (0.02)	-0.01 (0.02)	-0.01 (0.02)
Hosp. X Income	0.18 (0.16)	0.04 (0.36)	0.01 (0.02)	0.01 (0.02)	-0.04 (0.02)*
Constant	44.97 (0.44)**	44.28 (0.73)**	4.22 (0.05)**	4.06 (0.05)**	1.67 (0.06)**
Model 2: Interactions with Maternal Education					
Neonatal Risks	-1.79 (0.36)**	-1.65 (0.58)**	-0.09 (0.05)+	-0.04 (0.04)	0.03 (0.05)
Asthma Diagnosis	0.76 (0.49)	0.67 (0.60)	0.11 (0.05)*	0.03 (0.06)	-0.09 (0.06)
Acute Conditions	-0.01 (0.04)	0.01 (0.06)	-0.01 (0.00)+	0.00 (0.00)	0.01 (0.01)+
Poor Global Health	-1.29 (0.40)**	-1.68 (0.60)**	-0.07 (0.04)	-0.05 (0.04)	0.05 (0.05)
Hospitalization	-1.54 (0.51)**	-1.85 (0.65)**	-0.07 (0.05)	0.02 (0.05)	0.04 (0.06)
Maternal Education	0.97 (0.10)**	1.37 (0.17)**	0.02 (0.01)	0.01 (0.01)	0.03 (0.01)*
Neonatal X Education	-0.21 (0.18)	-0.19 (0.23)	0.03 (0.02)	0.01 (0.02)	-0.02 (0.02)
Asthma X Education	0.06 (0.22)	0.37 (0.30)	0.01 (0.03)	0.01 (0.03)	0.00 (0.03)
Acute X Education	-0.03 (0.01)*	-0.04 (0.03)+	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Poor Health X Education	-0.01 (0.18)	0.08 (0.28)	0.02 (0.02)	-0.01 (0.02)	-0.03 (0.02)
Hosp. X Education	0.24 (0.21)	-0.62 (0.31)*	0.03 (0.03)	0.02 (0.02)	-0.09 (0.02)**
Constant	44.63 (0.41)**	44.00 (0.66)**	4.22 (0.04)**	4.07 (0.04)**	1.64 (0.05)**

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$ Panel 1 contains interactions between health and family income-to-needs, and Panel 2 contains interactions between health and continuous maternal education. Covariates include ADHD and autism diagnosis, twin or triplet, child age, child gender, child race, months of kindergarten exposure, maternal age, non-English speaking household, immigrant household, marital status, minors in the household, child health insurance receipt, maternal employment, and public assistance receipt. Additionally, Model 1 controls for maternal education and Model 2 controls for family income.

Conditional indirect effects linking health and school readiness skills through early learning opportunities. The next set of analyses explored whether the mediating pathways linking children's health to school readiness skills through early learning contexts differed by level of family SES. Conditional process analysis, or moderated mediation, was conducted by running two sets of path models with interactions to test whether the mediating pathways varied as a function of family SES resources: one set

explored interactions with family income-to-needs and a second set tested interactions with maternal education (Table 10). Per Hayes' (2013) recommendation, each set was estimated using a fully interacted model, in which all pathways of interest were interacted with each SES indicator. The next steps involved probing significant interaction effects along the indirect pathways and then testing whether indirect effects through early learning contexts functioned only at certain levels of family income or maternal education.

In the path models interacted with family income, 4 of 20 interactions along the mediating pathways were significant, and in the set of models interacted with maternal education, 1 of 20 interactions along the mediating pathways were significant, indicating that only the models with income interactions contained significant interactions above the rate of chance. Yet, further probing of the income interactions effects revealed an unclear pattern of socioeconomic differences across these pathways that did not warrant further testing of conditional indirect effects linking children's health and school readiness through early learning contexts.

Table 10. Fully Interacted Path Models for Exploration of Conditional Indirect Effects

	Home Learning	Time in ECE	Math Skills	Reading Skills	Learning Skills	Prosocial Behaviors	Externalizing Problems
	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)
Model 1: Interactions with Family Income-to-Needs							
Health → Outcome							
Neonatal Risks	0.01 (0.02)	-0.03 (0.06)	-1.64 (0.36)**	-1.48 (0.60)*	-0.13 (0.07)*	-0.02 (0.05)	0.06 (0.07)
Asthma Diagnosis	0.05 (0.02)+	0.16 (0.10)	0.45 (0.55)	0.36 (0.69)	-0.01 (0.08)	0.08 (0.08)	0.06 (0.12)
Acute Conditions	0.00 (0.00)	0.03 (0.01)**	0.02 (0.04)	0.05 (0.06)	-0.01 (0.01)+	0.00 (0.01)	0.02 (0.01)
Poor Global Health	-0.06 (0.02)**	0.01 (0.06)	-1.21 (0.39)**	-1.74 (0.57)**	0.07 (0.07)	-0.14 (0.05)**	-0.10 (0.07)
Hospitalization	-0.03 (0.02)	-0.04 (0.09)	-1.45 (0.49)**	-1.46 (0.66)*	0.01 (0.06)	-0.03 (0.06)	-0.06 (0.07)
Family Income-to-Needs	0.01 (0.01)	0.10 (0.02)**	0.52 (0.11)**	0.93 (0.20)**	-0.01 (0.02)	0.03 (0.02)	0.01 (0.05)
Neonatal X Income	0.01 (0.01)	0.01 (0.03)	-0.09 (0.17)	-0.05 (0.24)	-0.03 (0.02)	0.02 (0.02)	0.03 (0.03)
Asthma X Income	0.00 (0.01)	0.03 (0.03)	-0.21 (0.21)	0.12 (0.30)	0.01 (0.03)	-0.02 (0.02)	-0.01 (0.05)
Acute X Income	0.00 (0.00)	0.00 (0.00)	0.01 (0.02)	-0.01 (0.03)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Poor Health X Income	0.01 (0.01)	0.05 (0.03)	0.35 (0.15)*	0.18 (0.23)	-0.03 (0.03)	0.01 (0.03)	0.04 (0.05)
Hosp. X Income	-0.02 (0.01)*	-0.05 (0.04)	0.19 (0.18)	0.07 (0.37)	0.07 (0.03)*	-0.02 (0.03)	-0.11 (0.04)**
Early Learning → Outcome							
Home Learning Activities	-	-	1.09 (0.23)**	1.49 (0.32)**	2.62 (0.02)**	-1.55 (0.07)**	-2.86 (0.13)**
Time in ECE (10 hours)	-	-	-0.10 (0.34)	0.03 (0.45)	-0.01 (0.01)	0.06 (0.23)	-0.15 (0.45)
Home X Income	-	-	0.16 (0.15)	0.39 (0.19)*	0.01 (0.01)	0.01 (0.01)	0.02 (0.01)
ECE X Income	-	-	-0.10 (0.03)**	-0.01 (0.01)*	0.00 (0.00)	0.00 (0.00)	0.01 (0.00)
Constant	0.36 (0.08)**	-0.70 (0.38)+	18.09 (2.10)**	12.40 (3.24**)	3.45 (0.31)**	5.04 (0.55)**	2.15 (1.07)*
Model 2: Interactions with Maternal Education							
Health → Outcome							
Neonatal Risks	0.01 (0.02)	-0.02 (0.06)	-1.74 (0.39)**	-1.67 (0.57)**	-0.09 (0.05)+	-0.02 (0.05)	0.03 (0.05)
Asthma Diagnosis	0.05 (0.02)*	0.14 (0.10)	0.64 (0.72)	0.24 (0.65)	0.10 (0.04)*	0.08 (0.10)	-0.13 (0.07)+
Acute Conditions	0.00 (0.00)	0.03 (0.01)**	0.00 (0.09)	0.02 (0.05)	-0.01 (0.00)	0.00 (0.01)	0.00 (0.01)
Poor Global Health	-0.05 (0.02)**	0.01 (0.06)	-1.40 (0.41)**	-1.39 (0.58)*	-0.06 (0.04)	-0.11 (0.05)**	0.06 (0.05)
Hospitalization	-0.03 (0.02)	-0.04 (0.09)	-1.55 (0.55)**	-1.60 (0.67)*	-0.06 (0.05)	-0.01 (0.06)	0.04 (0.06)

Maternal Education	0.06	(0.01)**	0.08	(0.02)**	1.00	(0.30)**	1.00	(0.18)**	0.01	(0.01)	0.07	(0.04)	0.00	(0.02)
Neonatal X Education	0.01	(0.01)	0.01	(0.04)	-0.20	(0.19)	-0.26	(0.24)	0.02	(0.02)	0.02	(0.02)	-0.02	(0.02)
Asthma X Education	0.00	(0.01)	0.01	(0.04)	0.09	(0.22)	0.42	(0.30)	0.01	(0.03)	0.01	(0.03)	0.00	(0.03)
Acute X Education	0.00	(0.00)	0.00	(0.00)	-0.04	(0.02)*	-0.05	(0.03)+	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)
Poor Health X Education	0.01	(0.01)	0.04	(0.03)	0.02	(0.23)	0.13	(0.26)	0.02	(0.02)	0.00	(0.03)	-0.04	(0.02)+
Hosp. X Education	-0.02	(0.01)	-0.07	(0.06)	0.29	(0.32)	-0.46	(0.32)	0.03	(0.03)	0.00	(0.04)	-0.07	(0.03)*
Early Learning → Outcome														
Home Learning Activities	-		-		-1.19	(0.93)	5.93	(0.33)**	0.18	(0.02)**	-1.16	(0.14)**	0.22	(0.05)**
Time in ECE (10 hours)	-		-		0.33	(3.18)	0.10	(0.51)	-0.01	(0.01)	0.04	(0.46)	0.18	(0.14)
Home X Education	-		-		-0.05	(0.19)	0.21	(0.26)	0.02	(0.02)	0.00	(0.02)	0.02	(0.02)
ECE X Education	-		-		-0.12	(0.04)**	-0.11	(0.07)	0.00	(0.01)	0.01	(0.00)	0.00	(0.00)
Constant	0.33	(0.08)**	-0.87	(0.38)*	18.03	(7.98)*	9.08	(3.29)**	4.26	(0.25)**	4.78	(1.12)**	1.96	(0.46)**

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$ Covariates include ADHD and autism diagnosis, twin or triplet, child age, child gender, child race, months of kindergarten exposure, maternal age, non-English speaking household, immigrant household, marital status, minors in the household, child health insurance receipt, maternal employment, and public assistance receipt. Additionally, Model 1 controls for maternal education and Model 2 controls for family income.

Three-way interactions between health, early learning opportunities, and family resources. Finally, analyses tested whether the compensatory or potentiating role of early learning opportunities linking health conditions and school readiness were moderated by family socioeconomic resources. These models, which included three-way interactions between health indicators, early learning contexts, and a family SES variable, were conducted in two sets: the first set assessed the moderating role of family income and the second tested the moderating role of maternal education. In both sets of income interactions, only 3 of 50 three-way interactions were statistically significant, just above the rate expected purely by chance. Additional probing of significant results revealed limited evidence that family SES moderated the relations between children's neonatal risks, early learning opportunities, and school readiness skills, and with no clear, replicated patterns emerging, suggesting that interactions between children's health conditions and early learning opportunities generally functioned similarly across levels of family SES resources (Tables 11a-11b).

Overall, results from models testing interactions with family income-to-needs and maternal education provide limited evidence that connections between early health conditions and children's school readiness skills varied across the SES spectrum. Although the proportion of significant interaction effects was slightly above the rate of chance, probing interaction effects did not yield evidence of a clear or notable pattern of differences across main effect, mediation, or moderation models linking children's health to their school readiness skills.

Table 11a. Three-Way Interactions Between Health, Early Learning Opportunities, and Family Income

	Math Skills	Reading Skills	Learning Skills	Prosocial Behaviors	Externalizing Problems
	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)
Neonatal Risks	-1.94 (0.41)**	-1.79 (0.64)**	-0.08 (0.05)	-0.01 (0.05)	0.03 (0.05)
Asthma Diagnosis	0.26 (0.60)	-0.01 (0.79)	0.10 (0.04)*	0.01 (0.06)	-0.10 (0.05)+
Acute Conditions	0.00 (0.04)	0.01 (0.07)	-0.01 (0.00)+	0.00 (0.00)	0.01 (0.00)
Poor Global Health	-1.13 (0.44)*	-1.55 (0.61)*	-0.05 (0.05)	-0.02 (0.04)	0.04 (0.05)
Hospitalization	-1.40 (0.52)**	-1.06 (0.70)	-0.05 (0.05)	0.03 (0.05)	0.02 (0.06)
Family Income to Needs	0.48 (0.11)**	0.56 (0.15)**	0.00 (0.01)*	0.02 (0.01)*	-0.02 (0.01)
Home Learning Activities	2.47 (0.44)**	3.61 (0.69)**	0.18 (0.04)**	0.07 (0.04)	-0.21 (0.04)**
Time in ECE	0.33 (0.10)**	0.88 (0.18)**	-0.03 (0.01)*	-0.01 (0.01)	0.06 (0.01)**
Neonatal X Home	-0.63 (0.93)	-0.81 (1.30)	0.01 (0.11)	0.07 (0.10)	0.14 (0.11)
Asthma X Home	0.33 (1.17)	2.17 (1.91)	-0.27 (0.13)*	-0.30 (0.13)*	0.29 (0.17)+
Acute X Home	-0.17 (0.11)	-0.12 (0.14)	0.01 (0.01)	0.01 (0.01)	-0.02 (0.01)*
Poor Health X Home	-0.29 (0.80)	0.50 (1.43)	-0.03 (0.10)	-0.02 (0.08)	-0.06 (0.12)
Hospitalization X Home	2.53 (1.29)*	-2.03 (2.02)	0.25 (0.16)	0.20 (0.12)+	-0.24 (0.20)
Neonatal X ECE	0.02 (0.24)	0.01 (0.30)	0.00 (0.03)	-0.02 (0.02)	0.00 (0.03)
Asthma X ECE	-0.16 (0.23)	-0.52 (0.32)	-0.04 (0.03)	-0.02 (0.03)	0.02 (0.03)+
Acute X ECE	0.00 (0.02)	0.00 (0.04)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Poor Health X ECE	-0.17 (0.25)	-0.15 (0.33)	0.01 (0.02)	0.00 (0.02)	-0.02 (0.03)*
Hospitalization X ECE	0.67 (0.31)*	0.74 (0.48)	0.07 (0.03)*	0.07 (0.03)*	-0.10 (0.03)
Interactions with Income					
Neonatal Risks	-0.20 (0.20)	-0.22 (0.27)	0.01 (0.02)	0.01 (0.02)	-0.01 (0.02)
Asthma Diagnosis	-0.25 (0.27)	0.01 (0.38)	0.02 (0.02)	0.01 (0.02)	-0.02 (0.02)
Acute Conditions	0.02 (0.02)	-0.01 (0.04)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Poor Health	0.33 (0.17)*	0.13 (0.24)	0.01 (0.02)	-0.01 (0.02)	-0.01 (0.02)
Hospitalization	0.15 (0.21)	0.22 (0.37)	0.01 (0.03)	0.01 (0.02)	-0.04 (0.02)+
Home Learning	0.11 (0.17)	0.46 (0.25)+	0.02 (0.02)	0.02 (0.01)	0.01 (0.02)
Time in ECE	-0.09 (0.04)*	-0.13 (0.06)*	0.00 (0.01)	0.00 (0.00)	0.00 (0.01)
Neonatal X Home	0.47 (0.36)	0.03 (0.46)	-0.06 (0.03)	-0.07 (0.03)*	0.02 (0.03)
Asthma X Home	0.17 (0.71)	0.80 (1.10)	0.01 (0.06)	0.04 (0.04)	0.07 (0.09)
Acute X Home	0.01 (0.05)	-0.02 (0.07)	0.01 (0.00)+	0.00 (0.00)	0.00 (0.00)
Poor Health X Home	0.09 (0.39)	0.13 (0.68)	-0.02 (0.04)	-0.06 (0.03)+	0.02 (0.05)
Hospitalization X Home	0.11 (0.53)	-1.50 (0.99)	-0.10 (0.05)+	-0.05 (0.03)+	0.02 (0.08)
Neonatal Risks X ECE	0.18 (0.10)+	0.42 (0.15)	0.01 (0.01)	0.00 (0.01)	-0.01 (0.01)
Asthma Diagnosis X ECE	-0.04 (0.12)	0.05 (0.17)	-0.01 (0.02)	-0.01 (0.02)	0.01 (0.02)
Acute Conditions X ECE	0.01 (0.01)	0.03 (0.02)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Poor Health X ECE	-0.11 (0.10)	-0.18 (0.15)	-0.01 (0.01)	-0.01 (0.01)	0.01 (0.01)
Hospitalization X ECE	-0.02 (0.14)	-0.14 (0.26)*	0.02 (0.02)	0.01 (0.02)	0.00 (0.01)
Constant	45.03 (0.44)**	44.40 (0.73)**	4.19 (0.05)**	4.04 (0.05)**	1.71 (0.05)**

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$ Covariates include ADHD and autism diagnosis, twin or triplet, child age, child gender, child race, months of kindergartene exposure, family income, maternal education, maternal age, non-English speaking household, immigrant household, marital status, minors in the household, child health insurance receipt, maternal employment, and public assistance receipt.

Table 11b. Three-Way Interactions Between Health, Early Learning Opportunities, and Maternal Education

	Math Skills	Reading Skills	Learning Skills	Prosocial Behaviors	Externalizing Problems
	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)
Neonatal Risks	-2.20 (0.43)**	-1.87 (0.67)**	-0.08 (0.05)	-0.03 (0.05)	0.04 (0.05)
Asthma Diagnosis	0.33 (0.58)	0.12 (0.71)	0.10 (0.05)*	0.01 (0.06)	-0.11 (0.06)+
Acute Conditions	-0.01 (0.04)	0.00 (0.07)	-0.01 (0.00)	0.00 (0.00)	0.01 (0.01)+
Poor Global Health	-1.24 (0.45)**	0.00 (0.07)*	-0.06 (0.05)	-0.04 (0.04)	0.02 (0.05)
Hospitalization	-1.27 (0.52)*	-1.38 (0.71)+	-0.04 (0.05)	0.06 (0.05)	0.03 (0.06)
Family Income to Needs	1.13 (0.23)**	1.55 (0.34)**	0.01 (0.02)	0.01 (0.02)	0.01 (0.02)
Maternal Education	2.25 (0.43)**	3.35 (0.69)**	0.20 (0.04)**	0.08 (0.04)*	-0.23 (0.04)**
Time in ECE	0.32 (0.10)**	0.85 (0.20)**	-0.02 (0.01)*	0.00 (0.01)	0.05 (0.01)**
Neonatal X Home	-0.59 (1.00)	-0.96 (1.34)	-0.01 (0.11)	0.10 (0.09)	0.15 (0.11)
Asthma X Home	-0.66 (1.06)	0.96 (1.63)	-0.32 (0.15)*	-0.39 (0.14)*	0.27 (0.17)+
Acute X Home	-0.11 (0.10)	-0.10 (0.13)	0.02 (0.01)	0.02 (0.01)	-0.02 (0.01)*
Poor Health X Home	0.94 (0.94)	1.06 (1.40)	-0.04 (0.11)	-0.02 (0.09)	0.02 (0.12)
Hospitalization X Home	2.38 (1.33)+	-0.59 (1.81)	0.25 (0.17)	0.18 (0.13)	-0.19 (0.19)
Neonatal X ECE	0.04 (0.23)	-0.05 (0.30)	-0.02 (0.03)	-0.02 (0.02)	0.01 (0.03)
Asthma X ECE	-0.10 (0.22)	-0.39 (0.33)	-0.04 (0.03)	-0.03 (0.03)	0.02 (0.03)
Acute X ECE	0.01 (0.02)	-0.01 (0.04)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Poor Health X ECE	-0.08 (0.24)	-0.06 (0.32)	0.02 (0.02)	0.00 (0.02)	-0.01 (0.02)
Hospitalization X ECE	0.67 (0.30)*	0.78 (0.44)+	0.06 (0.03)+	0.07 (0.03)*	-0.10 (0.03)**
Interactions with Education					
Neonatal Risks	-0.18 (0.19)	-0.17 (0.26)	0.03 (0.02)	0.00 (0.02)	-0.03 (0.02)
Asthma Diagnosis	0.09 (0.24)	0.33 (0.35)	0.03 (0.03)	0.04 (0.03)	-0.02 (0.03)
Acute Conditions	-0.03 (0.01)*	-0.05 (0.03)+	0.00 (0.00)	0.00 (0.00)+	0.00 (0.00)
Poor Health	-0.07 (0.20)	0.00 (0.30)	0.02 (0.02)	-0.01 (0.02)	-0.03 (0.02)
Hospitalization	0.20 (0.24)	-0.46 (0.36)	0.01 (0.03)	0.01 (0.02)	-0.07 (0.03)*
Home Learning	-0.12 (0.22)	0.25 (0.33)	0.03 (0.02)	0.00 (0.02)	0.00 (0.03)
Time in ECE	-0.10 (0.05)*	-0.08 (0.09)	0.00 (0.01)	0.01 (0.01)	-0.01 (0.01)
Neonatal X Home	1.09 (0.44)*	0.25 (0.59)	-0.03 (0.05)	-0.04 (0.04)	-0.01 (0.04)
Asthma X Home	-0.06 (0.49)	0.04 (0.71)	0.00 (0.06)	0.06 (0.05)	0.07 (0.07)
Acute X Home	0.01 (0.05)	0.00 (0.06)	0.00 (0.01)	0.00 (0.00)	-0.01 (0.01)
Poor Health X Home	0.53 (0.38)	0.42 (0.59)	-0.01 (0.05)	-0.02 (0.05)	0.08 (0.06)
Hospitalization X Home	-0.35 (0.56)	-0.91 (0.84)	-0.11 (0.07)	-0.14 (0.06)*	0.01 (0.08)
Neonatal Risks X ECE	0.12 (0.10)	0.28 (0.15)+	-0.01 (0.01)	0.00 (0.01)	0.00 (0.01)
Asthma Diagnosis X ECE	0.22 (0.13)+	0.25 (0.18)	-0.02 (0.02)	-0.03 (0.02)	0.03 (0.02)
Acute Conditions X ECE	0.01 (0.01)	0.01 (0.02)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)**
Poor Health X ECE	-0.14 (0.09)	-0.23 (0.17)	0.00 (0.01)	-0.01 (0.01)	-0.01 (0.01)
Hospitalization X ECE	-0.11 (0.16)	-0.13 (0.26)	0.01 (0.02)	0.01 (0.02)	-0.01 (0.02)
Constant	42.22 (0.44)**	44.55 (0.73)**	4.18 (0.05)**	4.06 (0.05)**	1.69 (0.05)**

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$ Covariates include ADHD and autism diagnosis, twin or triplet, child age, child gender, child race, months of kindergarten exposure, family income, maternal education, maternal age, non-English speaking household, immigrant household, marital status, minors in the household, child health insurance receipt, maternal employment, and public assistance receipt.

Alternate Specifications

Although this study incorporated rich, prospective longitudinal data and included an extensive set of child and family covariates to help isolate unique associations between children's health and school readiness skills, it nonetheless had to confront the numerous additional challenges inherent to all correlational research. Unmeasured variable bias, temporal precedence, and sample selection are primary concerns related to the secondary analysis of correlational data and hence, these issues were further explored in a series of robustness checks.

Adding additional covariates to address unmeasured variable bias. A first set of alternative models addressed concerns related to unmeasured heterogeneity. Analytic models for the first three aims described above were re-estimated including a measure of maternal psychological distress, averaged across Waves 1 through 3, and a Wave 1 measure of child functioning (a measure of cognitive ability in models predicting cognitive outcomes, or a measure of child temperament in models predicting behavioral outcomes). The inclusion of the measure of psychological distress functions as a check on parental bias in reports of the child's global health status and likelihood of hospitalization, as well as the quality of the home learning environment, which may be influenced by maternal functioning (Sills, Shetterly, Xu, Magid, & Kempe, 2007). The inclusion of indicators of child's early cognitive skills and temperament functioned as additional controls for unmeasured factors that have a consistent effect on children's functioning (Cain, 1975) and for characteristics that might function as evocative effects in regard to children's access to home and ECE-based learning opportunities, thus further reducing concerns of omitted variable bias. However, the inclusion of these variables as

proxies for lagged dependent variables is not ideal, considering that baseline functioning was measured when children were on average 10 months of age and thus were assessed after or in an overlapping timeframe with, rather than preceding the health measures. Results from these models indicate that the pattern of associations and the size of coefficients were consistent with results found in the main sets of models discussed previously (Table 12).

Table 12. Addressing Unmeasured Heterogeneity

	Predicting Mediators		Predicting School Readiness Skills				
	Home Learning	Time in ECE	Math Skills	Reading Skills	Learning Skills	Prosocial Behaviors	Externalizing Problems
	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)
Model 1: RQ1							
Neonatal Risks			-1.32 (0.55)*	-1.46 (0.36)**	-0.10 (0.05)*	-0.04 (0.04)	0.04 (0.05)
Asthma Diagnosis	-	-	0.46 (0.59)	0.64 (0.50)	0.10 (0.04)*	0.02 (0.05)	-0.08 (0.06)
Acute Conditions	-	-	0.02 (0.06)	-0.00 (0.04)	-0.01 (0.00)	0.00 (0.00)	0.01 (0.01)
Poor Global Health	-	-	-1.84 (0.57)**	-1.31 (0.38)**	-0.06 (0.04)	-0.03 (0.04)	0.05 (0.05)
Hospitalization	-	-	-1.57 (0.59)**	-1.54 (0.49)**	-0.08 (0.05)	0.02 (0.05)	0.05 (0.06)
Additional Covariates							
Maternal Psych. Distress	-	-	0.03 (0.05)	-0.03 (0.04)	-0.01 (0.00)*	-0.01 (0.00)*	0.01 (0.01)*
Child Cognitive Skills	-	-	0.04 (0.02)+	0.05 (0.01)**	-	-	-
Child Temperament	-	-	-	-	0.08 (0.03)**	0.08 (0.03)**	-0.03 (0.03)
Constant	-	-	-20.8 (4.77)**	-8.96 (3.26)**	3.60 (0.37)**	3.89 (0.32)**	1.71 (0.42)**
Model 2: RQ2							
Neonatal Risks	0.01 (0.02)	-0.03 (0.06)	-1.39 (0.36)**	-1.23 (0.55)*	-0.10 (0.05)*	-0.04 (0.04)	0.04 (0.05)
Asthma Diagnosis	0.05 (0.02)*	0.14 (0.10)	0.30 (0.53)	0.00 (0.60)	0.10 (0.04)*	0.02 (0.05)	-0.08 (0.06)
Acute Conditions	0.00 (0.00)	0.03 (0.01)**	0.00 (0.04)	0.01 (0.06)	-0.01 (0.00)	0.00 (0.00)	0.01 (0.01)
Poor Global Health	-0.06 (0.02)**	-0.02 (0.06)	-1.20 (0.39)**	-1.66 (0.55)**	-0.05 (0.04)	-0.03 (0.04)	0.04 (0.05)
Hospitalization	-0.02 (0.02)	-0.02 (0.09)	-1.43 (0.49)**	-1.38 (0.61)*	-0.07 (0.05)	0.02 (0.05)	0.04 (0.06)
Home Learning	-	-	2.78 (0.41)**	3.94 (0.56)**	0.18 (0.04)*	0.06 (0.04)	-0.20 (0.04)**
Time in ECE	-	-	0.40 (0.09)**	0.90 (0.14)**	-0.02 (0.01)	0.00 (0.01)	0.04 (0.01)**
Additional Covariates							
Maternal Psych. Distress	-0.01 (0.00)**	-0.01 (0.01)	-0.02 (0.05)	0.04 (0.05)	-0.01 (0.00)*	-0.01 (0.00)*	0.01 (0.01)**
Child Cognitive Skills	0.00 (0.00)	0.00 (0.00)	0.06 (0.01)**	0.06 (0.02)**	-	-	-
Child Temperament	0.00 (0.01)	-0.15 (0.07)*	-	-	0.08 (0.03)**	0.08 (0.03)**	-0.02 (0.03)
Constant	0.39 (0.08)**	-1.08 (0.45)*	13.23 (2.18)**	6.91 (3.29)*	4.32 (0.24)**	4.30 (0.20)**	1.60 (0.29)**

Model 3: RQ3										
Neonatal Risks	-	-	-1.44	(0.37)**	-1.30	(0.56)*	-0.10	(0.05)*	-0.03	(0.04)	0.04	(0.05)
Asthma Diagnosis	-	-	0.28	(0.54)	0.03	(0.61)	0.08	(0.04)+	0.01	(0.05)	-0.06	(0.06)
Acute Conditions	-	-	0.00	(0.04)	0.01	(0.06)	-0.01	(0.00)	0.00	(0.00)	0.01	(0.00)
Poor Global Health	-	-	-1.17	(0.40)**	-1.63	(0.57)**	-0.05	(0.04)	-0.03	(0.04)	0.03	(0.05)
Hospitalization	-	-	-1.40	(0.48)**	-1.45	(0.61)*	-0.06	(0.05)	0.02	(0.05)	0.03	(0.06)
Home Learning	-	-	2.57	(0.43)**	3.93	(0.68)**	0.18	(0.04)**	0.07	(0.04)+	-0.18	(0.04)**
Time in ECE	-	-	0.33	(0.10)**	0.87	(0.19)**	-0.03	(0.01)*	-0.01	(0.01)	0.06	(0.01)**
Neonatal X Home	-	-	-1.19	(0.90)	-1.51	(1.20)	0.04	(0.11)	0.10	(0.09)	0.11	(0.11)
Asthma X Home	-	-	-0.48	(0.96)	1.52	(1.48)	-0.26	(0.13)*	-0.31	(0.12)**	0.22	(0.15)
Acute X Home	-	-	-0.14	(0.09)	-0.13	(0.13)	0.01	(0.01)	0.01	(0.01)	-0.02	(0.01)
Poor Health X Home	-	-	0.17	(0.78)	0.14	(1.29)	-0.01	(0.10)	-0.03	(0.08)	-0.09	(0.10)
Hospitalization X Home	-	-	2.58	(1.20)*	-1.14	(1.71)	0.29	(0.15)*	0.22	(0.12)+	-0.30	(0.17)+
Neonatal X ECE	-	-	-0.11	(0.24)	-0.28	(0.31)	-0.01	(0.03)	-0.02	(0.02)	0.00	(0.03)
Asthma X ECE	-	-	-0.12	(0.23)	-0.42	(0.29)	-0.03	(0.03)	-0.01	(0.03)	0.00	(0.03)
Acute X ECE	-	-	0.00	(0.02)	-0.01	(0.03)	0.00	(0.00)	0.00	(0.00)	0.01	(0.00)+
Poor Health X ECE	-	-	0.03	(0.22)	0.08	(0.29)	0.02	(0.02)	0.00	(0.02)	-0.02	(0.02)
Hospitalization X ECE	-	-	0.67	(0.30)*	0.78	(0.43)+	0.07	(0.03)*	0.07	(0.03)*	-0.11	(0.03)**
Additional Covariates	-	-										
Maternal Psych. Distress	-	-	-0.02	(0.05)	0.04	(0.05)	-0.01	(0.00)*	-0.01	(0.00)*	0.01	(0.01)**
Child Cognitive Skills	-	-	0.06	(0.01)**	0.06	(0.02)**	-		-		-	
Child Temperament	-	-	-		-		0.08	(0.03)**	0.08	(0.02)**	-0.03	(0.03)
Constant	-	-	40.56	(1.28)**	39.94	(1.85)**	4.21	(0.05)**	4.06	(0.05)**	1.66	(0.06)**

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$ Covariates include ADHD and autism diagnosis, twin or triplet, child age, child gender, child race, months of kindergarten exposure, family income, maternal education, maternal age, non-English speaking household, immigrant household, marital status, minors in the household, child health insurance receipt, maternal employment, and public assistance receipt.

Establishing temporal precedence. A second set of alternate model specifications focused more carefully on the issue of temporal precedence and the timing of the main measures. According to leading developmental scientists (McCartney, Burchinal & Bub, 2006), one of the criteria for drawing causal inferences from non-experimental data is for measurement of independent variables to precede measurement of dependent variables. In the models previously presented, temporal precedence could not be established due to a decision to fully exploit the richness of these data by drawing on measures of children's health that incorporated all points of measurement from 10 months through 4 years of age (Waves 1-3), which captured the time frame from birth through the year prior to school entry. In additional analyses, in order to most cleanly establish temporal precedence in this study, models were adjusted such that health indicators were drawn from Waves 1 and 2, learning opportunities from Wave 3, and school readiness skills from Wave 4. Results from these models revealed similar results to those discussed in detail above (Table 13).

In models replicating Aim 1, results revealed that neonatal risks and poor health predicted lower math (0.15 SDs), reading (0.10 SDs), and learning skills (0.13 SDs), and hospitalization predicted lower math (0.15 SDs) and reading (0.10 SDs) skills, which were very similar to effect sizes from original models. In contrast, associations between poor health and school readiness were less frequent and weaker (0.09 SDs), and associations between hospitalization and school readiness were stronger (0.12-0.17 SDs).

In the mediation models, results replicate earlier findings that home learning functioned as a mediator linking poor health to children's school readiness skills and that acute conditions predicted time in ECE, with effect sizes of nearly the same magnitude as

main models. However, these alternative models found no evidence of associations between asthma and home learning, and instead, showed that asthma diagnosis by Wave 2 was associated with more time in ECE at Wave 3 (0.14 SDs). Finally, replication of the models conducted for Aim 3 revealed the same pattern in size and direction of interaction effects, in which interactions between asthma and home learning, hospitalization and home learning, and hospitalization and ECE participation predicted children's math, learning, prosocial, and externalizing behaviors. In short, results from the main models were generally replicated in models assessing children's health only until age 2, although some patterns of results weakened slightly. Despite that fact that this alternative set of models established temporal precedence, these models suffered from a long time lag between the measurement of health problems (at 9 months and 2 years) and children's school readiness skills in kindergarten (at age 5), and miss important information on children's health during the preschool years.

Table 13. Establishing Temporal Precedence

	Predicting Mediators		Predicting School Readiness Skills				
	Home Learning	Time in ECE	Math Skills	Reading Skills	Learning Skills	Prosocial Behaviors	Externalizing Problems
	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)
Model 1: RQ1							
Neonatal Risks$_{1-2}$	-	-	-1.71 (0.38)**	-1.59 (0.58)**	-0.10 (0.05)*	-0.04 (0.04)	0.04 (0.05)
Asthma Diagnosis$_{1-2}$	-	-	0.85 (0.62)	0.99 (0.75)	0.06 (0.06)	0.01 (0.06)	-0.02 (0.07)
Acute Conditions$_{1-2}$	-	-	0.00 (0.05)	0.06 (0.06)	-0.00 (0.01)	0.00 (0.01)	0.01 (0.01)
Poor Global Health$_{1-2}$	-	-	-0.82 (0.42)+	-1.39 (0.60)*	-0.00 (0.05)	-0.00 (0.04)	-0.01 (0.05)
Hospitalization$_{1-2}$	-	-	-1.73 (0.52)**	-1.84 (0.68)**	-0.12 (0.06)*	-0.00 (0.05)	0.10 (0.07)
Constant	-	-	-7.24 (3.06)*	-19.10 (4.77)**	3.58 (0.37)**	3.87 (0.32)**	1.75 (0.42)**
Model 2: RQ2							
Neonatal Risks$_{1-2}$	0.01 (0.02)	-0.03 (0.06)	-1.68 (0.38)**	-1.54 (0.58)**	-0.10 (0.05)*	-0.04 (0.04)	0.04 (0.05)
Asthma Diagnosis$_{1-2}$	0.03 (0.03)	0.22 (0.10)*	0.56 (0.65)	0.52 (0.76)	0.06 (0.05)	0.01 (0.06)	-0.02 (0.07)
Acute Conditions$_{1-2}$	0.00 (0.00)	0.03 (0.01)*	-0.00 (0.05)	0.04 (0.06)	-0.00 (0.01)	0.00 (0.01)	0.01 (0.01)
Poor Global Health$_{1-2}$	-0.05 (0.02)**	-0.03 (0.06)	-0.71 (0.43)	-1.18 (0.59)*	0.01 (0.05)	0.00 (0.04)	-0.02 (0.05)
Hospitalization$_{1-2}$	-0.02 (0.03)	0.02 (0.11)	-1.70 (0.52)**	-1.74 (0.68)*	-0.11 (0.06)*	0.00 (0.05)	0.08 (0.07)
Home Learning$_{3}$	-	-	2.83 (0.40)**	3.93 (0.55)**	0.19 (0.04)**	0.06 (0.04)+	-0.21 (0.04)**
Time in ECE$_{3}$	-	-	0.40 (0.09)**	0.90 (0.14)**	-0.02 (0.01)+	0.00 (0.01)	0.04 (0.01)**
Constant	0.35 (0.08)**	-1.01 (0.39)**	16.36 (1.97)**	10.22 (3.06)**	4.31 (0.25)**	4.30 (0.20)**	1.65 (0.29)**
Model 3: RQ3							
Neonatal Risks$_{1-2}$	-	-	-1.73 (0.38)**	-1.61 (0.58)**	-0.10 (0.05)*	-0.04 (0.04)	0.04 (0.05)
Asthma Diagnosis$_{1-2}$	-	-	0.56 (0.67)	0.66 (0.77)	0.05 (0.06)	0.00 (0.06)	0.00 (0.06)
Acute Conditions$_{1-2}$	-	-	0.00 (0.05)	0.04 (0.07)	0.00 (0.01)	0.00 (0.01)	0.01 (0.01)
Poor Global Health$_{1-2}$	-	-	-0.66 (0.45)	-1.11 (0.61)+	0.01 (0.05)	0.00 (0.04)	-0.02 (0.05)
Hospitalization$_{1-2}$	-	-	-1.67 (0.52)**	-1.87 (0.68)**	-0.11 (0.05)*	0.00 (0.05)	0.08 (0.06)
Home Learning$_{3}$	-	-	2.54 (0.42)**	3.86 (0.67)**	0.19 (0.04)**	0.08 (0.04)+	-0.19 (0.04)**
Time in ECE$_{3}$	-	-	0.33 (0.10)**	0.87 (0.19)**	-0.03 (0.01)*	-0.01 (0.01)	0.06 (0.01)**

Neonatal X Home	-	-	-1.26	(0.92)	-1.55	(1.23)	0.02	(0.11)	0.09	(0.09)	0.12	(0.11)
Asthma X Home	-	-	-0.33	(0.95)	1.64	(1.52)	-0.26	(0.13)*	-0.30	(0.12)*	0.23	(0.15)
Acute X Home	-	-	-0.14	(0.09)	-0.13	(0.13)	0.01	(0.01)	0.01	(0.01)	-0.01	(0.01)
Poor Health X Home	-	-	0.46	(0.79)	0.46	(1.30)	0.01	(0.10)	-0.01	(0.08)	-0.11	(0.10)
Hospitalization X Home	-	-	2.47	(1.21)*	-1.28	(1.72)	0.28	(0.15)+	0.21	(0.12)+	-0.29	(0.17)+
Neonatal X ECE	-	-	-0.11	(0.24)	-0.27	(0.30)	-0.01	(0.03)	-0.02	(0.02)	0.01	(0.03)
Asthma X ECE	-	-	-0.16	(0.22)	-0.48	(0.29)+	-0.03	(0.03)	-0.01	(0.03)	0.01	(0.03)
Acute X ECE	-	-	0.00	(0.02)	-0.01	(0.03)	0.00	(0.00)	0.00	(0.00)	0.01	(0.00)+
Poor Health X ECE	-	-	0.05	(0.22)	0.10	(0.29)	0.03	(0.02)	0.01	(0.02)	-0.03	(0.02)
Hospitalization X ECE	-	-	0.69	(0.31)*	0.80	(0.43)+	0.07	(0.03)*	0.07	(0.03)*	-0.11	(0.03)**
Constant	-	-	44.87	(0.45)**	44.27	(0.75)**	4.18	(0.05)**	4.04	(0.04)**	1.70	(0.05)**

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$ Covariates include ADHD and autism diagnosis, twin or triplet, child age, child gender, child race, months of kindergarten exposure, family income, maternal education, maternal age, non-English speaking household, immigrant household, marital status, minors in the household, child health insurance receipt, maternal employment, and public assistance receipt.

Average early learning opportunities from Waves 1 through 3. Related to the question of temporal precedence is a concern over measuring home learning activities and ECE only at age 4. In the models previously presented, children's early learning opportunities in the home and in ECE were drawn only from Wave 3, motivated by the literature arguing that learning experiences, particularly those in ECE, in the year prior to kindergarten are most crucial for the development of children's school readiness skills (High, 2008; Snow, 2006). Yet, an alternative possibility may be that children's exposure to these early learning contexts from infancy through preschool better explains variability in school readiness skills at kindergarten entry. To address these issues, another set of alternative model specifications were conducted in which measures of home learning activities and time in center-based ECE were drawn from Waves 1 through 3 (with measures averaged over the waves) to capture a more complete picture of children's exposure to these early learning experiences throughout the first 4 years of life prior to school entry. Similar to results from main models, these results revealed that asthma diagnosis predicted more home learning activities, and poor health predicted more limited home learning activities (Table 14). Acute conditions also predicted more time in ECE. In regard to school readiness outcomes, home learning again predicted higher pre-academic and learning skills and lower externalizing problems, and time in ECE predicted higher pre-academic skills and externalizing problems. Across these models, the magnitude of effect sizes for links between time in ECE and school readiness skills increased, but otherwise the pattern of results discussed previously were generally replicated. Although these models provide a fuller view of children's access to enriching opportunities, they suffer from drawbacks including the inability to establish temporal

precedence or illuminate bidirectional associations linking children's health conditions and early learning contexts across the first 4 years of children's lives. Additional analyses further examining the unexpected associations between children's acute conditions and time in ECE, which emerged in main models and were replicated in these models, are presented in Appendix B.

Table 14. Learning Opportunities From Infancy Through Early Childhood

	Predicting Mediators		Predicting School Readiness Skills				
	Home Learning$_{1-3}$	Time in ECE$_{1-3}$	Math Skills	Reading Skills	Learning Skills	Prosocial Behaviors	Externalizing Problems
	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)
Neonatal Risks$_{1-3}$	-0.01 (0.02)	0.00 (0.00)	-1.52 (0.38)**	-1.33 (0.56)*	-0.10 (0.05)*	-0.04 (0.04)	0.04 (0.05)
Asthma Diagnosis$_{1-3}$	0.06 (0.02)**	0.01 (0.01)+	0.31 (0.53)	-0.01 (0.60)	0.10 (0.04)*	0.02 (0.06)	-0.09 (0.06)
Acute Conditions$_{1-3}$	0.00 (0.00)+	0.00 (0.00)**	-0.01 (0.04)	0.01 (0.06)	-0.01 (0.00)	0.00 (0.00)	0.01 (0.01)
Poor Global Health$_{1-3}$	-0.08 (0.01)**	0.00 (0.00)	-1.23 (0.39)**	-1.64 (0.55)**	-0.06 (0.04)	-0.04 (0.04)	0.05 (0.05)
Hospitalization$_{1-3}$	-0.02 (0.02)	0.00 (0.01)	-1.47 (0.50)**	-1.45 (0.62)*	-0.08 (0.05)	0.02 (0.05)	0.05 (0.06)
Home Learning$_{1-3}$	-	-	2.57 (0.52)**	3.42 (0.69)**	0.18 (0.05)**	0.11 (0.04)*	-0.20 (0.05)**
Time in ECE$_{1-3}$	-	-	7.16 (2.09)**	14.26 (3.01)**	-0.38 (0.20)+	-0.08 (0.18)	0.87 (0.20)**
Constant	0.40 (0.07)**	-0.06 (0.02)**	16.61 (1.98)**	10.66 (3.13)**	4.30 (0.25)**	4.27 (0.20)**	1.67 (0.28)**

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$ Covariates include ADHD and autism diagnosis, twin or triplet, child age, child gender, child race, months of kindergarten exposure, family income, maternal education, maternal age, non-English speaking household, immigrant household, marital status, minors in the household, child health insurance receipt, maternal employment, and public assistance receipt.

Sample selection. As a final robustness check, alternative models were estimated using the entire ECLS-B sample that includes children with severe physical health conditions and disabilities whose families stayed in the study through Wave 4. Final models examining main associations between health and school readiness, indirect associations through early learning opportunities, and interacted associations between health and early learning opportunities were replicated with this more inclusive sample. Including the entire sample provides a nationally representative picture of these associations across the cohort of children born in 2001 and highlights whether associations differ with the inclusion of children with more severe health concerns.

As shown in the first panel of Table 16, analyses replicating the first aim revealed a similar pattern of results, with neonatal risks and poor health predicting lower math, reading, and learning skills, and hospitalization predicting lower math and reading skills. Again, asthma diagnosis predicted heightened learning skills. These models also revealed that poor health predicted lower prosocial behaviors (-0.11 SDs). On the whole, effect sizes in these alternative models were modestly stronger, ranging from 0.14 to 0.20 SDs for math skills, 0.09 to 0.15 SDs for reading, and 0.15 to 0.16 SDs for learning skills, in comparison to 0.13 to 0.15 SDs for math skills, 0.10 to 0.12 SDs for reading skills, and 0.11 to 0.13 SDs for learning skills.

In models replicating Aim 2 (second panel of Table 16), the pattern of results was also similar to main models. Asthma diagnosis predicted higher home learning activities (0.12 SDs) and poor health predicted lower home learning activities (-0.14 SDs), where as acute conditions continued to predict more time in ECE (0.06 SDs). As noted above, associations between children's health conditions and school readiness skills were

modestly stronger in these alternative models than in main models, even after controlling for early learning contexts. In these models, as in the main models, neonatal risks and hospitalization continued to function directly to predict lower cognitive and learning skills. Additionally, indirect effects linked asthma to higher math, reading, learning and lower externalizing through higher home learning environments, and poor health was indirectly linked to lower math, reading, learning and higher externalizing through more restricted home learning environments. Also, results again replicated unexpected associations in which children's acute conditions predicted more time in ECE.

In the third panel of Table 16, analyses replicating Aim 3 surprisingly revealed limited evidence that the home or ECE contexts served a compensatory role for the development of cognitive, learning, or behavioral skills among children who were hospitalized. Only one significant interaction emerged between home and acute conditions to predict math skills, which did not appear in prior models, and one significant interaction emerged between ECE and hospitalization to predict externalizing problems, reflecting a similar finding in the main models. In general, these results suggest that greater time in early learning contexts does not serve a compensatory role when the sample includes children with disabilities, who may be constrained in the extent to which they can fully engage in or benefit from learning opportunities in these contexts.

Table 16. RQ1, RQ2, RQ3 Analyses Replicated in Full ECLS-B Sample

	Predicting Mediators		Predicting School Readiness Skills				
	Home Learning	Time in ECE	Math Skills	Reading Skills	Learning Skills	Prosocial	Externalizing
	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)
Model 1: RQ1							
Neonatal Risks	-	-	-2.00 (0.35)**	-1.83 (0.47)**	-0.11 (0.04)**	-0.06 (0.04)	0.05 (0.04)
Asthma Diagnosis	-	-	0.66 (0.49)	0.45 (0.54)	0.08 (0.04)*	-0.01 (0.06)	-0.03 (0.05)
Acute Conditions	-	-	0.02 (0.04)	0.03 (0.05)	-0.00 (0.00)	0.00 (0.00)	0.01 (0.01)+
Poor Global Health	-	-	-1.81 (0.34)**	-2.30 (0.50)**	-0.12 (0.04)**	-0.07 (0.03)*	0.06 (0.04)
Hospitalization	-	-	-1.40 (0.51)**	-1.42 (0.63)*	-0.06 (0.05)	0.06 (0.04)	0.05 (0.05)
Constant	-	-	-6.03 (2.88)*	-18.05 (4.02)**	3.62 (0.34)**	3.87 (0.31)**	1.79 (0.41)**
Model 2: RQ2							
Neonatal Risks	0.00 (0.02)	-0.06 (0.05)	-1.96 (0.35)**	-1.76 (0.46)**	-0.12 (0.04)**	-0.06 (0.04)	0.06 (0.04)
Asthma Diagnosis	0.05 (0.02)*	0.09 (0.09)	0.40 (0.52)	0.10 (0.56)	0.07 (0.04)+	-0.01 (0.06)	-0.02 (0.05)
Acute Conditions	0.00 (0.00)	0.02 (0.01)**	0.02 (0.04)	0.02 (0.05)	-0.00 (0.00)	0.00 (0.00)	0.01 (0.01)
Poor Global Health	-0.06 (0.02)**	-0.02 (0.07)	-1.70 (0.33)**	-2.15 (0.48)**	-0.11 (0.04)**	-0.07 (0.03)*	0.05 (0.04)
Hospitalization	-0.01 (0.02)	0.07 (0.10)	-1.34 (0.50)**	-1.36 (0.64)*	-0.06 (0.04)	0.06 (0.04)	0.04 (0.05)
Home Learning	-	-	2.95 (0.38)**	3.76 (0.50)**	0.19 (0.04)**	0.09 (0.04)*	-0.21 (0.04)**
Time in ECE	-	-	0.30 (0.10)**	0.80 (0.20)**	-0.00 (0.00)+	0.00 (0.00)	0.00 (0.00)**
Constant	0.35 (0.09)**	-0.16 (0.36)	16.21 (1.77)**	9.78 (2.53)**	4.30 (0.22)**	4.15 (0.18)	1.74 (0.28)**
Model 3: RQ3							
Neonatal Risks	-	-	-2.00 (0.35)**	-1.80 (0.47)**	-0.12 (0.04)**	-0.06 (0.04)	0.06 (0.04)
Asthma Diagnosis	-	-	0.38 (0.53)	0.02 (0.56)	0.06 (0.04)	-0.02 (0.06)	-0.01 (0.05)
Acute Conditions	-	-	0.02 (0.04)	0.03 (0.05)	0.00 (0.00)	0.00 (0.00)	0.01 (0.00)
Poor Global Health	-	-	-1.72 (0.34)**	-2.14 (0.49)**	-0.11 (0.04)**	-0.07 (0.04)*	0.05 (0.04)
Hospitalization	-	-	-1.35 (0.50)**	-1.41 (0.65)*	-0.05 (0.04)	0.06 (0.04)	0.03 (0.05)
Home Learning	-	-	2.74 (0.41)**	3.81 (0.62)**	0.19 (0.04)**	0.11 (0.04)**	-0.19 (0.04)**
Home X Neonatal	-	-	-0.86 (0.89)	0.97 (1.06)	0.03 (0.10)	0.04 (0.08)	0.10 (0.10)
Home X Asthma	-	-	0.15 (1.02)	1.56 (1.30)	-0.25 (0.12)	-0.22 (0.11)+	0.08 (0.15)
Home X Acute	-	-	-0.16 (0.08)*	-0.09 (0.13)	0.01 (0.01)	0.01 (0.01)	-0.01 (0.01)+
Home X Poor Health	-	-	-0.33 (0.79)	-0.34 (1.22)	-0.02 (0.10)	-0.02 (0.07)	-0.09 (0.10)
Home X Hosp.	-	-	2.41 (1.28)+	-0.96 (1.57)	0.18 (0.12)	0.02 (0.11)	-0.13 (0.15)

Time in ECE	-	-	0.21	(0.13)	0.81	(0.20)**	-0.03	(0.01)*	-0.01	(0.01)	0.05	(0.01)**
ECE X Neonatal	-	-	0.17	(0.32)	0.01	(0.33)	0.02	(0.03)	0.01	(0.02)	0.01	(0.03)
ECE X Asthma	-	-	0.22	(0.22)	-0.29	(0.28)	-0.02	(0.03)	-0.00	(0.03)	0.00	(0.04)
ECE X Acute	-	-	0.00	(0.02)	-0.01	(0.03)	-0.00	(0.00)	-0.00	(0.00)	0.00	(0.00)
ECE X Poor Health	-	-	0.05	(0.26)	0.08	(0.32)	0.01	(0.03)	0.00	(0.02)	0.01	(0.03)
ECE X Hosp.	-	-	0.16	(0.35)	0.17	(0.45)	0.06	(0.04)	0.05	(0.03)	-0.10	(0.04)**
Constant	-	-	44.38	(0.44)**	43.97	(0.68)	4.19	(0.04)**	4.05	(0.05)**	1.69	(0.05)**

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$ Covariates include ADHD and autism diagnosis, twin or triplet, child age, child gender, child race, months of kindergarten exposure, family income, maternal education, maternal age, non-English speaking household, immigrant household, marital status, minors in the household, child health insurance receipt, maternal employment, and public assistance receipt.

CHAPTER 7: DISCUSSION

Over the past decade, a cadre of researchers has sought to establish children's health as a national priority given the essential nature of health for human capital development across the lifecourse (NRC/IOC, 2004). Early health is an integral component of children's optimal development (Case & Paxson, 2006), but recent national statistics raise continued concern about the health of young children (DHHS HRSA, 2013; CDC, 2013). Indeed, children commonly experience a variety of health insults in the early years of life (Wise, 2004), warranting greater attention to the breadth of children's experiences that may influence their readiness for formal schooling. In line with these concerns, the NRC/IOM argues that child health should be re-defined to capture the ability to "a) develop and realize their potential, b) satisfy their needs, and c) develop the capacities to allow them to interact successfully with the biological, physical, and social environments" (pg. 33). Based on this proposition, this dissertation tested whether links between physical health and school readiness skills in a birth cohort of U.S. children functioned through early learning conduits informed by developmental theory. The primary aims included illuminating the mediating and moderating roles of early learning contexts and clarifying differences in associations between early health and school readiness skills across the family SES spectrum. Results revealed that four of the five indicators of children's health were uniquely associated with school readiness skills, most consistently with cognitive skills, with patterns revealing direct effects, indirect effects, and interacted effects with home- and ECE-based learning contexts. Findings also showed no clear pattern of differences in the magnitude or direction of associations linking health to school readiness across the SES spectrum.

Understanding Roles of Individual Health Conditions

By including a diverse range of health indicators, this dissertation identified unique associations linking dimensions of physical health to various domains of school readiness skills. Of these health indicators, only neonatal risks functioned directly, but not indirectly or interactively, to predict lower pre-academic and learning skills. These results may reflect the neurobiological repercussions of low birth weight and premature birth that include reduced brain size, neurodevelopmental disabilities, and related medical conditions (Reichman, 2005). Across studies drawing on both small epidemiological samples and population-based samples (Poehlman et al., 2010; Morse et al., 2009), as well as those employing quasi-experimental research designs (Goosby & Cheadle, 2009), the broad consensus in the literature is that early health insults present at birth have significant short- and long-term implications for children's cognitive functioning and abilities to learn (Almond & Currie, 2005).

Similar to neonatal risks, parental reports of their child's poor health status also predicted lower pre-academic and learning skills, with links functioning in part indirectly through more restricted home learning activities. These findings may be attributed to the possibility that parents view the child as physically unable to participate in activities like going to the library or taking an arts class, and as a result, restrict access to these experiences. Alternatively, parents may find caring for a sick child so psychologically demanding that they have less time or energy to facilitate home-based learning activities like book-reading.

After controlling for home and ECE contexts, direct links between children's poor health and pre-academic and learning skills held, suggesting that negative associations

with poor health might be partly attributable to biological factors resulting from side effects of children's treatments or physical discomfort from illnesses (Currie, 2005) that cannot be explained by parents' home-based engagement with the child. Furthermore, results revealed evidence of inconsistent mediation in which poor health predicted higher externalizing problems indirectly through home learning, even though no direct effect existed, signifying that some unmeasured processes counteract this negative indirect effect to yield a null main effect (MacKinnon et al., 2007). One explanation may be that children in poor health are provided fewer peer play opportunities, which promote early socialization processes (Vaughn et al., 2000). Despite these possibilities, it is important to acknowledge that the relation between poor health and home learning may be due to shared method variance, since mothers reported on both domains, although results held in models incorporating measures of mothers' psychological functioning and earlier child functioning, easing concerns over reporter bias.

Children's experiences of hospitalization for asthma attacks and respiratory infections were also directly associated with their pre-academic skills in the domains of math and reading, and like neonatal risks, did not function indirectly through early learning contexts. These findings provide additional support for the neurobiological repercussions of experiencing or treating severe illnesses that require immediate medical attention (Currie, 2005). However, interactions with early learning contexts revealed that higher quality home learning environments and more time in ECE were associated with heightened pre-academic and behavioral functioning among children who were hospitalized. These findings are evidence of the compensatory effect of early learning contexts (Bradley et al., 2010), suggesting that greater engagement in these contexts can

attenuate the negative associations between hospitalization and school readiness skills. In other words, hospitalization might be experienced as a more deleterious health insult for children in lower quality home learning environments and children spending limited time in center ECE who do not have the added supports to maintain optimal development during a crucial developmental window. One surprising finding from these results was the benefit of these contexts for cognitive, self-regulatory, and behavioral functioning, since center ECE has been linked with detriments in children's behavior (Belsky et al., 2007; Coley et al., 2013; Loeb et al., 2007). It may be the case, as studies often show with socioeconomically disadvantaged children, that children experiencing a broad range of risks to optimal development experience unique benefits of certain early learning contexts (Gormley & Gayer, 2005; Watamura et al., 2010; Votruba-Drzal et al., 2013; Winsler et al., 2008).

In comparison to neonatal risks, poor health, and hospitalization, asthma diagnosis was associated in a more limited fashion in the development of school readiness skills, only directly predicting learning skills. Given that learning skills capture traits like attention, persistence, and motivation, which are essential aspects of self-regulatory behaviors (Blair, 2002), one possibility is that the treatment routines required to control a child's asthma symptoms are advantageous in promoting the child's self-regulatory abilities. Treatment for asthma may include numerous doctor visits and a rigorous schedule of medications (Leikly et al., 1998), which could enhance a child's patience and frustration tolerance and ultimately promote learning skills.

In regard to indirect pathways, asthma diagnosis predicted greater home learning activities, and although indirect effects linking asthma to domains of school readiness

through the home learning environment were not statistically significant, the link between asthma and the home are worth discussing. There are two likely explanations for the finding that asthma diagnosis predicts greater home learning activities; one explanation is that many children with asthma are sensitive to seasonal allergens (Héguy et al., 2008) or are unable to play outside with peers without risk of an asthma attack, potentially leading to restricted time outdoors and greater opportunities for parents to facilitate learning opportunities in the home or in libraries and museums. An alternative explanation is related to unmeasured bias, suggesting that children who have access to higher quality home learning environments may also have routine access to health care and consequently, are more likely to obtain an asthma diagnosis. One surprising finding was that asthma interacted with home learning to predict learning skills and prosocial behaviors, with benefits of home learning only accumulated to children without asthma. The unclear implications of these interaction effects may be attributed to the tremendous variability in symptomology and severity of children's asthma. For example, some children may have asthma conditions that are well-maintained through an established treatment regimen, where as other children may experience serious symptoms frequently necessitating emergency medical care.

In summary, with the exception of acute conditions, all of children's health indicators appeared to play a meaningful role in relation to the emergence of school readiness skills, with patterns most consistent for pre-academic and learning skills. Acute conditions, which included ear and respiratory infections, are characterized by the generally brief and easy to treat nature of these conditions, and as a result, may not be strongly associated with cognitive or behavioral indicators of children's development.

Indeed, results revealed that acute conditions only predicted greater time in ECE, but additional analyses uncovered the confounding of this association with children's exposure to larger peer group size. In short, these associations highlight the challenges of illustrating selection processes, which are the product of complex decisions involving child and family characteristics, parental employment and education, and cultural values around child care, among others (Coley et al., 2014; Early & Burchinal, 2002).

Limited Differences Across the Socioeconomic Spectrum

A final aim of this research was to assess whether direct, indirect, and interacted associations linking children's physical health, early learning contexts, and school readiness skills differed across the socioeconomic spectrum. Testing moderation of these pathways by family income and maternal education revealed very limited significant associations and no notable pattern of results. Few studies have explored whether associations between health and development differ across socioeconomic strata, but findings from this research are in line with other population-level research showing that children experience the negative effects of low birth weight on cognitive skills similarly across socioeconomic strata (Figlio et al., 2013).

The null associations for interactions with family SES is surprising, given that SES disparities in health and development are some of the most robust findings across the social science literature. There is broad consensus that low SES children experience worse health and greater impairments in development that are evident within the early years of children's lives (Braveman & Barclay, 2009; Brooks-Gunn et al., 2007; Fiscella et al., 2000; McLoyd, 1998). These findings may be due in part to the fact that children in low SES families experience greater threats to health that include inadequate prenatal

care and nutrition, environmental hazards and contagions in their homes and neighborhoods, elevated maternal stress, and restricted access to routine health care (Currie, 2009; Newacheck et al., 1996; Reichman, 2005; Weinick & Krauss, 2000), reflecting the widespread challenges that low SES families face in preventing or remedying health problems that might influence children's early developmental competencies. Despite evidence for a SES gradient in health across the literature, results from this research yielded null interaction effects with both family income-to-needs and maternal education, indicating that the magnitude and direction of these associations were experienced equally across the population.

However, it should not be inferred from these null interaction effects that socioeconomic status plays a limited role at this intersection. In line with the literature, descriptive results in this dissertation demonstrate that early health insults are not equally distributed across the population of young U.S. children. Indeed, low-SES children more commonly experience neonatal risks, asthma diagnosis, poor health, and hospitalization, which were the indicators most consistently associated with lower math, reading and learning skills. Hence, negative associations between health problems and school readiness skills function in an additive way, with low-SES children experiencing a greater accumulation of health insults that may independently impair the development of their competence in cognitive, learning, and behavioral domains. Currie and Stabile (2002) find a similar pattern of results in a study examining why associations between poor health and family SES become stronger over time. The authors find that low- and high-SES children recover equally as well from health insults due to medical services and treatment, but the sheer number of health insults that low-SES children experience

accumulates over the first two decades of life to impair youth's health. They also find no interactions between early health and SES predicting children's cognitive functioning in middle childhood, but do find that SES attenuates the negative effects of recent health insults in middle childhood. In short, results are in line with other population-based studies indicating that children across socioeconomic strata may experience health insults equally, but the greater accumulation of health problems that low-SES children experience may have more negative long-term implications.

Contributions to the Literature

Findings from this dissertation extend the literature on children's health and development in a few novel ways. First, this research provides more comprehensive views of children's physical health and school readiness skills, which are warranted based on extant literature asserting that these domains of human functioning are multi-dimensional and should be operationalized as such (NRC/IOM, 2004; Snow, 2006). By examining multiple health indicators, this research captures broader associations between health and development than much prior research, which has typically focused on only one or two dimensions of health (Halterman et al., 2001; Morse et al., 2009; Roberts et al., 2000). Examining neonatal risks, acute and chronic health conditions, an indicator of the severity of these conditions, and an overall assessment of global health permits identification of the unique associations between distinct indicators of health, controlling for other indicators, and children's school readiness skills. Likewise, this research examines a broader range of children's developmental competencies at the crucial developmental transition that involves the start of formal schooling, where as many other studies on this topic in the early elementary school years have focused on single

indicators of cognitive functioning (Crosnoe, 2006; Spernak et al., 2006), obscuring the potentially pervasive links between children's health and development. Indeed, this research finds direct and indirect links between health and learning skills, as well as interacted associations between health and the ECE context predicting behavioral functioning. Most notably, the consistent pattern of associations for learning skills, which include essential elements of self-regulatory abilities, such as frustration tolerance and motivation to learn (Blair, 2002), is in line with the pattern of results for math and reading skills. Studies have shown that learning skills are integral to trajectories of academic achievement across elementary school (Duncan et al., 2007; McClelland et al., 2006), emphasizing the value of understanding determinants of learning skills.

Second, this research further illuminates a potential developmental mechanism, as hypothesized by the bioecological framework (Bronfenbrenner & Morris, 1998; Sameroff & Chandler, 1975) that links children's health to their development by exploring the mediating and moderating roles of early learning contexts. Findings from these analyses extend the literature on two fronts. In regard to the mediating role of early learning contexts, findings add support to the literature testing propositions about parents' likelihood of investing in children with the greatest chances of economic success (Becker & Tomes, 1976). Much of this recent literature draws on sibling samples and indicates that parents generally do not make greater educational or psychological investments in their healthier children (Datar et al., 2010; Hsin, 2012; Lynch & Brooks, 2013). Using less rigorous modeling techniques, this study's results suggesting that parents' restrictions of sick children's access to home-based learning activities may in fact be driven by unmeasured family characteristics. Furthermore, findings from models testing

interactions between health, home learning, and time in ECE extend the literature on the heterogeneity of associations connecting children's early learning contexts and their emerging school readiness skills. Prior literature has examined whether early learning contexts have differential benefits for subgroups of children, often focused on children facing socioeconomic disadvantage (Caughy et al., 1994; Miller et al., 2014; Pluess & Belsky, 2010; Votruba-Drzal et al., 2004; Votruba-Drzal et al., 2013; Watamura et al., 2011), and has found early learning contexts to more often play a compensatory role. In line with the literature, findings from this research show that early learning contexts may also help children impaired by other threats to well-being, such as experiences of hospitalization, by preventing further impairments in comparison to their healthier peers.

A final valuable contribution of this research is the use of a nationally representative sample of children born in 2001 and followed from infancy through kindergarten entry. The use of this diverse sample permitted testing whether associations between children's health and school readiness differed across levels of family income and maternal education. Much literature on this topic has been limited to either small epidemiological samples or samples drawing on restricted economic strata and racial/ethnic subgroups (Halterman et al., 2001; Roberts et al., 2000; Spernak et al., 2006), thus constraining variability in family SES necessary for testing differences across the SES spectrum. This research is the first to examine whether associations between children's early physical health and development at school entry differ across levels of family income and maternal education in a nationally representative study of U.S. children.

Limitations and Future Directions

Of course, contributions of this research must be viewed in light of its limitations. First and foremost, although this research employed rich prospective data from a nationally representative sample of children, these data and the methods used to analyze them are correlational, which preclude drawing causal inferences (Duncan, Magnuson, & Ludwig, 2004). Despite this, all efforts were taken to protect against the force of omitted variable bias by rigorously controlling statistical models and exploring numerous robustness checks. Results from Appendix A suggest that some of the associations between children's health and school readiness skills may shared variability with measured family characteristics, reflecting concerns about collinearity of predictors and potentially downwardly biasing estimates. These model-based approaches to the problem of multicollinearity and omitted variable bias unfortunately cannot completely eliminate this concern, and hence, results should be interpreted as associational.

Second, this research encountered numerous issues in understanding the directionality of some associations, such as the links between acute conditions and time in ECE. These challenges were due in part to the infrequent measurement points in the ECLS-B, which includes only four interviews with parents over five years, thus yielding data that are not measured on a fine enough grain to illuminate nuances in the directionality of associations. Another explanation for issues related to identifying the directionality of the constructs of interest may be that these constructs are connected in different ways, according to alternative theoretical models that differ from the model informed by the bioecological framework used in this study.

A third limitation of this research is the operationalization of children's health variables. With the exception of neonatal risks that were drawn from birth certificates, parents reported on all other health variables. Reliance on parental reports creates a number of problems, including shared method variance with children's early learning contexts, since parents also reported on children's home learning activities and time in ECE. Given that parents reported whether children's health problems were diagnosed by medical professionals, the estimates of children's health conditions may actually be conservative, because some parents may have chosen not to have the child diagnosed and treated even if the child displayed symptoms of an illness. Relatedly, parent reports of children's diagnoses led to crude operationalization of these variables, as in the case of a dichotomous indicator for asthma diagnosis. This variable does not capture the variability or maintenance of the condition, and the severity of asthma could only be assessed through a dichotomous indicator of hospitalization. This operationalization may explain the limited findings with asthma diagnosis, considering that prior work has found negative associations between asthma diagnosis and cognitive functioning when diagnosis was accompanied by a functional limitation (Halterman et al., 2001).

In light of these limitations, this research has important implications for future research. As noted above, more rigorous research designs and methodologies are needed to identify the causal associations linking children's early health problems and the development of their school readiness skills. Studies should seek to exploit both natural experiments, such as those used by economists to test the fetal origins hypothesis (Almond & Currie, 2011), as well as true experiments, like the Head Start Impact Study, to identify whether high quality learning experiences compensate for impairments

associated with hospitalization and to further illuminate other mechanisms linking health and development. In regard to issues of bidirectionality in the relation between acute conditions and time in ECE, research attempting to elucidate the role of children's peer exposure at this intersection could benefit from studies conducted with more frequent data points, such as the National Institute for Child Health and Development's (NICHD) Study of Early Child Care and Youth Development, which interspersed phone interviews every three months between five major assessments across the first three years of the study (NICHD Early Child Care Research Network, 1994).

On the measurement side, a priority for future research should include a valid and reliable multi-dimensional measure of children's overall health. Some studies suggest that a single item indicator, the parental rating of the child's global health status, sufficiently captures overall health (Bowling, 2005; McCormick, 2008) and has good predictive validity (Kull & Coley, under review; Reichman, Corman, & Noonan, 2004), but it is unknown what constitutes a rating of "poor" health or how parents evaluate the child's health. Other researchers have called for greater measurement development that fully accounts for the multi-faceted nature of children's health (NRC/IOM, 2004). Clarifying the processes involved in parents' perceptions of the child's health and understanding how parents respond to the child based on these perceptions, as well as developing a multi-dimensional scale of children's health, are important next steps.

Implications for Practice and Policy

Results from this research also highlight potential avenues for improving practice and policy in the domains of children's health and development. In regards to practice, preschool and kindergarten teachers may play important overlooked roles in attending to

the health of children by helping to identify symptoms of illnesses and connecting children with resources for treatment. Moreover, findings from this research underscore the importance of pediatricians, nurses, and medical social workers in promoting child development. In the wake of a medical event that requires a child to be hospitalized or to engage in other forms of medical treatment, these individuals may have opportunities to discuss topics such as child development and resilience with parents (High, 2008), who should be encouraged to provide stimulating learning opportunities to children even after an insult to the child's health has occurred.

Although policy recommendations can be difficult to draw from correlational analyses, findings emphasize the value of prevention and intervention efforts for reducing children's early health problems, promoting development, and integrating these dual goals. In regard to prevention, research in public health and epidemiology has identified policy levers in maternal health behaviors, access to prenatal care, and environmental exposures, which influence children's health conditions early in life (Currie, 2009; Reichman, 2005). Other work finds that the expansion of the Children's Health Insurance Program (CHIP) has dramatically increased low SES children's access to health insurance and care and may be integral in increasing access to preventive health services, but concerns remain about inequities in quality of care and program take-up (Currie, 2009; Swartz, 2009). The recent enactment of the Affordable Care Act may attenuate some of these concerns by extending and improving coverage among many families who previously did not qualify for Medicaid or CHIP (Morrissey, 2012).

Along with more widespread preventive efforts, children may also benefit from intervention approaches that synchronize health and educational programs to maximize

well-being (Fiscella & Kitzman, 2009). Studies suggest that intervention is most cost-effective early in life (Schweinart et al., 2005), and two of the most promising approaches include family-based early interventions, such as the Nurse-Family Partnership, and center-based services with family components like Early Head Start and Head Start (Love et al., 2005; Olds et al., 2004). These programs have shown some encouraging results in improving child health and well-being and maternal functioning, and in response, various policy initiatives have emerged at both the federal level to rigorously evaluate a model for a nation-wide maternal-child home-visiting program and at the state level to implement universal preschool. Additionally, among children attending ECE centers, a third consideration may be identifying the appropriate fit between the child and his or her ECE program (Bradley et al., 2011), such that children experiencing health issues are paired with comprehensive ECE programs that address multiple facets of well-being and can connect families to health resources for children.

Conclusion

Overall, this dissertation extends the literature on children's health and development in important ways, by revealing the nuanced associations linking children's health conditions from birth through age 4, early learning contexts, and developmental competencies at school entry. Findings raise awareness of the importance of considering specific domains of individual's early physical health in regard to their access and engagement in early learning opportunities and in turn to their readiness for formal schooling. A central takeaway point is the need for more interdisciplinary research at the intersection of children's health and development to identify causal mechanisms and points of prevention and intervention (Fiscella & Kitzman, 2009; Shonkoff, 2012). As a

field, it is important to more fully understand the role of children's health in their early human capital development, considering the burgeoning body of literature asserting that school readiness skills set the foundation for long-term academic, educational, and labor market success (Duncan et al., 2007; Knudsen et al., 2006). Greater knowledge of the relations between health and development is needed to design more effective programs and policies that support the well-being of young children and promote optimal development across the lifecourse.

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APPENDIX A: MODEL BUILDING PROCESS

The process of model building for baseline models that examined main associations between children's health indicators and school readiness skills occurred in a series of steps, which first addressed the operationalization of children's health variables, then explored the robustness of links between health and school readiness skills to various sets of covariates, and finally, checked that covariates were also associated with measures of children's health as well as development.

Robustness of effects for neonatal risks to other health conditions. A primary consideration in examining the operationalization of children's health variables was the balance between developmental theory and empirical justifications. The primary models argued that each of the health indicators was a unique condition with the potential to independently affect child functioning. Another hypothesis is that neonatal risks predispose children to develop poorer health and more acute health conditions in early childhood, thereby influencing later development (Almond & Currie, 2011). In order to test this hypothesis, models were estimated with children's health variables entered sequentially to first assess the effects of neonatal risks, along with the full set of covariates, and then adding in the other health predictors to check for a reduction in the size of the neonatal risks coefficient (Appendix Table A1). Results from these models indicated that the addition of the asthma, acute conditions, general health, and hospitalization variables to the models did not substantially minimize the size of the coefficients for neonatal risks or reduce the statistical significance of these variables; in models without additional health predictors, neonatal risks predicted lower math, reading, and learning skills on the order of 0.17 SDs, 0.11 SDs, and 0.14 SDs, respectively, where

as neonatal risks predicted lower math, reading, and learning skills with effect sizes of 0.15 SDs, 0.10 SDs, and 0.13 SDs, respectively, in models including the other health variables. Drawing on result presented below in Appendix Table A5, Sobel tests were conducted to test whether neonatal risks were also indirectly linked with children's school readiness skills through susceptibility to other health conditions. Results revealed that neonatal risks indirectly predicted lower math skills through poor health (z = -2.81) and hospitalization (z = -2.57) and lower reading skills through poor health (z = 2.66) and hospitalization (z = 2.26). These findings suggest that neonatal risks function both indirectly and additively with other early childhood health conditions to influence children's early developmental competencies.

Appendix Table A1. Robustness of Neonatal Risks to Other Health Indicators

	Math Skills	Reading Skills	Learning Skills	Prosocial Behaviors	Externalizing Problems
	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)
Model 1: Neonatal Risks Only					
Neonatal Risks	-1.83 (0.37)**	-1.73 (0.59)**	-0.11 (0.05)*	-0.04 (0.04)	0.04 (0.05)
Constant	-7.53 (3.07)*	-19.25 (4.74)**	3.57 (0.38)**	3.87 (0.32)**	1.77 (0.42)
Model 2: Include Other Health Indicators					
Neonatal Risks	-1.62 (0.37)**	-1.48 (0.57)**	-0.10 (0.05)*	-0.06 (0.06)	0.04 (0.05)
Asthma Diagnosis	0.67 (0.51)	0.48 (0.60)	0.10 (0.05)*	0.04 (0.08)	-0.09 (0.06)
Acute Conditions	0.00 (0.04)	0.03 (0.06)	-0.01 (0.00)	0.00 (0.01)	0.01 (0.01)+
Poor Global Health	-1.37 (0.38)**	-1.85 (0.56)**	-0.08 (0.04)*	-0.07 (0.06)	0.07 (0.05)
Hospitalization	-1.56 (0.49)**	-1.59 (0.60)**	-0.08 (0.05)	0.03 (0.07)	0.05 (0.06)
Constant	-7.10 (3.07)*	-18.82 (4.76)**	3.56 (0.38)**	0.40 (0.47)	1.78 (0.42)**

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$ Cova riates include ADHD and autism diagnosis, twin or triplet, child age, child gender, child race, months of kindergarten exposure, family income, maternal education, maternal age, non-English speaking household, immigrant household, marital status, minors in the household, child health insurance receipt, maternal employment, and public assistance receipt.

Associations between specific neonatal risks and school readiness skills. A related concern is the possibility that specific neonatal risks, either premature birth or low birth weight, might drive associations with children's development. Indicators for low birth weight (< 2500 grams) and premature birth (less than 37 weeks' gestation) were

individually entered into models predicting school readiness, along with covariates and the other health indicators, and revealed that both low birth weight (-0.09 SDs) and premature birth (-0.26 SDs) uniquely predicted lower math, but neither individual variable significantly predicted reading or learning skills (Appendix Table A2). Given that 95% of premature children were also classified as low birth weight, the combination of these correlated variables was appropriate.

Appendix Table A2. Links Between Specific Neonatal Risks and School Readiness Skills

	Math Skills	Reading Skills	Learning Skills	Prosocial Behaviors	Externalizing Problems
	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)
Low Birth Weight	-0.94 (0.41)*	-0.83 (0.61)	-0.09 (0.05)+	-0.07 (0.05)	0.04 (0.05)
Premature Birth	-2.65 (0.78)**	-2.22 (1.32)+	-0.11 (0.08)	0.02 (0.06)	0.07 (0.12)
Asthma Diagnosis	0.67 (0.51)	0.48 (0.60)	0.10 (0.05)*	0.03 (0.06)	-0.09 (0.06)
Acute Conditions	0.00 (0.04)	0.03 (0.06)	-0.01 (0.00)	0.00 (0.00)	0.01 (0.01)+
Poor Global Health	-1.37 (0.38)**	-1.86 (0.56)**	-0.08 (0.04)*	-0.05 (0.04)	0.06 (0.05)
Hospitalization	-1.53 (0.49)**	-1.56 (0.60)**	-0.08 (0.05)	0.02 (0.05)	0.05 (0.06)
Constant	-7.06 (3.08)*	-18.78 (4.76)**	3.57 (0.38)**	3.86 (0.32)**	1.78 (0.42)**

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$ Cova riates include ADHD and autism diagnosis, twin or triplet, child age, child gender, child race, months of kindergarten exposure, family income, maternal education, maternal age, non-English speaking household, immigrant household, marital status, minors in the household, child health insurance receipt, maternal employment, and public assistance receipt.

Investigating developmental timing of health conditions. There is also the possibility that the timing of children's physical health problems was differentially associated with the emergence of school readiness skills. Considering the tenet of lifecourse theory that health problems at birth and in infancy may be particularly detrimental for later functioning (Halfon & Hochstein, 2002), analyses tested whether health problems experienced in infancy (Wave 1), as compared to health problems experienced in toddlerhood and early childhood (Waves 2 to 3), were stronger predictors of child functioning (Appendix Table A3). Results revealed poor health experienced in toddlerhood and early childhood, as opposed to infancy, drove associations with lower

math (-0.13 SDs) and learning skills (-0.13 SDs) and higher externalizing problems (0.14 SDs). Poor health at either time predicted approximately 0.10 SDs lower reading skills. However, hospitalization experienced in infancy predicted 0.18 SDs lower math skills. Additionally, counter to expectations, acute conditions in infancy predicted 0.03 SDs higher reading skills, whereas acute conditions in toddlerhood and childhood predicted 0.06 SDs lower learning skills. These findings highlight some of the nuances in timing underlying the broad operationalizations of children's health conditions captured from infancy through early childhood.

Appendix Table A3. Developmental Timing of Health Conditions

	Math Skills	Reading Skills	Learning Skills	Prosocial Behaviors	Externalizing Problems
	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)
Neonatal Risk	-1.62 (0.37)**	-1.46 (0.57)*	-0.10 (0.05)*	-0.04 (0.04)	0.04 (0.05)
Asthma Diagnosis$_{1}$	0.22 (0.72)	0.79 (0.80)	0.12 (0.08)	0.13 (0.08)	-0.10 (0.08)
Asthma Diagnosis$_{2-3}$	0.80 (0.67)	0.30 (0.72)	0.06 (0.05)	-0.03 (0.06)	-0.04 (0.06)
Acute Conditions$_{1}$	0.02 (0.09)	0.22 (0.10)*	0.01 (0.01)	0.01 (0.01)	-0.00 (0.01)
Acute Conditions$_{2-3}$	-0.01 (0.08)	-0.03 (0.11)	-0.02 (0.01)*	-0.01 (0.01)	0.01 (0.01)
Poor Health$_{1}$	-0.37 (0.49)	-1.53 (0.69)*	-0.01 (0.05)	0.04 (0.04)	-0.05 (0.06)
Poor Health$_{2-3}$	-1.45 (0.41)**	-1.64 (0.57)**	-0.09 (0.05)*	-0.07 (0.04)+	0.11 (0.05)*
Hospitalization$_{1}$	-1.89 (0.61)**	-1.18 (0.83)	-0.09 (0.08)	-0.09 (0.07)	0.10 (0.10)
Hospitalization$_{2-3}$	-1.25 (0.66)+	-1.40 (0.88)	0.00 (0.08)	0.09 (0.06)+	-0.01 (0.06)
Constant	-6.82 (3.07)*	-18.77 (4.79)**	3.61 (0.38)**	3.90 (0.32)**	1.72 (0.42)**

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$ Cova riates include ADHD and autism diagnosis, twin or triplet, child age, child gender, child race, months of kindergarten exposure, family income, maternal education, maternal age, non-English speaking household, immigrant household, marital status, minors in the household, child health insurance receipt, maternal employment, and public assistance receipt.

Examining robustness of associations to covariates. In a second set of exploratory models examining main associations between children's health conditions and school readiness skills, covariates were entered hierarchically to test the robustness of final operationalizations of children's health variables to an increasingly rigorous set of covariates (Appendix Table A4). The first model included health and only child covariates and showed that neonatal risks predicted lower math skills (-0.19 SDs), reading skills (-0.14 SDs), and learning skills (-0.17 SDs); acute conditions predicted

higher externalizing problems (0.05 SDs); poor health predicted lower math skills (-0.22 SDs), reading skills (-0.22 SDs), and learning skills (-0.14 SDs); hospitalization predicted lower math skills (-0.19 SDs) and reading skills (-0.14 SDs). As expected, these models indicate that children's health conditions were associated with moderately lower pre-academic and learning skills.

The second and third sets of models included income and maternal education individually to delineate their unique contributions to school readiness skills that might share variance with children's health conditions. Although the magnitude of the effect sizes for the health variables modestly decreased, the pattern of significant associations is similar for Models 2 and 3 as compared to Model 1. A few differences emerged in the model controlling for income, in which acute conditions predicted lower learning skills (-0.06 SDs), and in the model controlling for education, the associations between acute conditions and externalizing problems became non-significant.

The fourth set of models added family human capital and household structure characteristics, such as immigrant household and marital status, to the child, income, and maternal education covariates. These models revealed a further modest decrease in the size of the coefficients linking children's neonatal risks, poor health, and hospitalization to their pre-academic and learning skills. Two differences in these sets of models were that asthma diagnosis positively predicted learning skills (0.13 SDs) and acute conditions no longer significantly predicted externalizing problems. In the final set of models that included covariates for public assistance receipt and child health insurance receipt, the magnitude of these associations held. Across all school readiness outcomes, the inclusion of the full set of covariates reduced the size of the coefficients for associations between

children's health and development by about 20% to 40%, suggesting that children's health conditions were also associated with other child and family characteristics, but patterns of significance generally remained stable across the models.

Appendix Table A4. Robustness of Health Indicators to Covariates

	Math Skills	Reading Skills	Learning Skills	Prosocial Behaviors	Externalizing Problems
	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)
Model 1: Health and Child Covariates					
Neonatal Risks	-2.07 (0.40)**	-2.10 (0.61)**	-0.13 (0.05)**	-0.06 (0.04)	0.07 (0.05)
Asthma Diagnosis	0.23 (0.57)	-0.12 (0.66)	0.07 (0.05)	0.00 (0.06)	-0.05 (0.06)
Acute Conditions	-0.00 (0.04)	0.02 (0.06)	-0.01 (0.00)+	0.00 (0.00)	0.01 (0.01)*
Poor Global Health	-2.37 (0.45)**	-3.35 (0.64)**	-0.10 (0.04)*	-0.07 (0.04)+	0.07 (0.05)
Hospitalization	-2.04 (0.61)**	-2.18 (0.78)**	-0.09 (0.05)+	0.02 (0.05)	0.07 (0.06)
Constant	-4.78 (3.20)	-17.49 (5.28)**	3.53 (0.35)**	3.85 (0.30)**	1.66 (0.40)**
Model 2: Health, Child Covariates, Household					
Neonatal Risks	-1.76 (0.36)**	-1.67 (0.58)**	-0.12 (0.05)*	-0.05 (0.04)	0.06 (0.05)
Asthma Diagnosis	0.56 (0.52)	0.31 (0.62)	0.09 (0.05)+	0.01 (0.06)	-0.06 (0.06)
Acute Conditions	-0.01 (0.04)	0.02 (0.05)	-0.01 (0.00)*	0.00 (0.00)	0.01 (0.01)*
Poor Global Health	-1.81 (0.41)**	-2.60 (0.61)**	-0.09 (0.04)*	-0.05 (0.04)	0.05 (0.05)
Hospitalization	-1.67 (0.54)**	-1.70 (0.68)*	-0.09 (0.05)+	0.02 (0.05)	0.07 (0.06)
Constant	-12.25 (3.18)**	-27.64 (5.12)**	3.28 (0.36)**	3.63 (0.30)**	1.87 (0.42)**
Model 3: Health, Child Covariates, Maternal Education					
Neonatal Risks	-1.74 (0.37)**	-1.65 (0.59)**	-0.12 (0.05)**	-0.06 (0.04)	0.07 (0.05)
Asthma Diagnosis	0.31 (0.53)	-0.05 (0.62)	0.08 (0.05)+	0.01 (0.06)	-0.06 (0.06)
Acute Conditions	-0.01 (0.04)	0.01 (0.06)	-0.01 (0.00)+	0.00 (0.00)	0.01 (0.01)+
Poor Global Health	-1.69 (0.41)**	-2.40 (0.59)**	-0.09 (0.04)*	-0.06 (0.04)	0.06 (0.05)
Hospitalization	-1.91 (0.53)**	-2.03 (0.69)**	-0.09 (0.05)+	0.02 (0.05)	0.08 (0.06)
Constant	-5.20 (3.14)+	-18.17 (4.86)**	3.45 (0.35)**	3.80 (0.30)**	1.71 (0.40)**
Model 4: Health, Child Covariates, Household Income, Maternal Education, Family Human Capital					
Neonatal Risks	-1.66 (0.36)**	-1.54 (0.57)**	-0.10 (0.05)*	-0.04 (0.04)	0.04 (0.05)
Asthma Diagnosis	0.56 (0.51)	0.35 (0.60)	0.09 (0.05)*	0.02 (0.06)	-0.07 (0.06)
Acute Conditions	-0.00 (0.04)	0.03 (0.06)	-0.01 (0.00)+	0.00 (0.00)	0.01 (0.01)+
Poor Global Health	-1.41 (0.39)**	-1.90 (0.57)**	-0.09 (0.04)*	-0.05 (0.04)	0.07 (0.05)
Hospitalization	-1.65 (0.50)**	-1.69 (0.63)**	-0.08 (0.05)	0.02 (0.05)	0.06 (0.06)
Constant	-9.13 (3.00)**	-21.50 (4.68)**	3.44 (0.38)**	3.81 (0.32)**	1.87 (0.43)**

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$ Cova riates include ADHD and autism diagnosis, twin or triplet, child age, child gender, child race, months of kindergarten exposure, family income, maternal education, maternal age, non-English speaking household, immigrant household, marital status, minors in the household, child health insurance receipt, maternal employment, and public assistance receipt. Model 1 contains only child characteristic covariates. Model 2 controls for child characteristics and household income, and Model 3 controls for maternal education. Model 4 adds household structure and maternal characteristics as covariates.

Predicting children's physical health conditions. Finally, child, family and household characteristics included as covariates were used to predict the health constructs of interest (Appendix Table A5). For neonatal risks, covariates included only those that could be drawn from Wave 1 and either did not occur after diagnosis of a neonatal risk or were unlikely to have changed in response to a child's neonatal risk (e.g., maternal education). These covariates include twin or triplet status, child gender, child race, maternal age, maternal education, non-English speaking household, and immigrant household. For models predicting children's asthma diagnosis, acute conditions, poor health, and hospitalization captured by age 4 (Wave 3), covariates were the same as those in main models, excluding variables assessed after Wave 3, such as exposure to kindergarten. Due to issues with model convergence, these models were estimated in Stata Version 13 using jackknife survey estimation and missing data were addressed using listwise deletion, reducing the analytic sample to 5,200.

Logistic regressions were used to predict neonatal risks, asthma diagnosis, poor health, and hospitalization, and a negative binomial regression was used to predict acute conditions, based on evidence that the variance of acute conditions was overdispersed (Long, 1997). In the model predicting neonatal risks, results showed that the neonatal risks of low birth weight and premature birth were more likely among children who were a twin or triplet (OR = 21.12), were female (OR = 1.34), were Black as opposed to White (OR = 2.64), and among children of lower educated mothers (OR = 1.42). Across all of the other health indicators, with the exception of acute conditions, neonatal risks subsequently predicted a greater likelihood of asthma diagnosis (OR = 1.79), poor health (OR = 1.72), and hospitalization (OR = 1.92). Results from these models indicated that

children's characteristics were related to their health conditions; ADHD diagnosis predicted a greater likelihood of asthma diagnosis (OR = 3.78), Autism Spectrum diagnosis predicted a greater likelihood of poor health (OR = 4.14), and being male predicted a greater likelihood of asthma diagnosis (OR = 1.46), acute conditions (IRR = 1.20), poor health (OR = 1.52), and hospitalization (OR = 1.40). Family human capital characteristics, such as income and maternal marital status, played a limited role in explaining health indicators, and beyond the association with neonatal risks, low maternal education only predicted a lower likelihood of the child's acute condition diagnoses (IRR = 0.82). Children in non-English speaking households were less likely to be diagnosed with acute conditions (IRR = 0.71) but more likely to be in poor health (OR = 2.16). Additionally, children who always had public health insurance across the first four years of life were more likely to be hospitalized (OR = 1.43) and children of mothers who were either unemployed (IRR = 0.76) or not stably employed (IRR = 0.89) were less likely to be diagnosed with acute conditions. Finally, across all of the health indicators measured from birth to age 4, children in families who received public assistance were more likely to be diagnosed with asthma (OR = 2.14) and acute conditions (OR = 1.27), and also more likely to be in poor health (OR = 1.43) and be hospitalized (OR = 1.93).

In short, these results serve two functions: they support the selection of covariates for all models and they facilitate understanding of some of the more complex issues, such as those around bidirectional associations between ECE and acute conditions. Results from these models indicate that child, family, and household characteristics selected for inclusion in models predicting children's school readiness are well justified because they also predicted children's health. Second, results suggest that acute condition diagnoses

may reflect families' greater access to medical care, with diagnoses associated with human and cultural capital characteristics such as being White, English speaking, more educated, and stably employed. These results highlight the possibility that the measure of acute conditions used in this study may have limited validity as an assessment of the frequency of children's illnesses, suggesting instead, that more empirical attention is needed in operationalizing acute health conditions in early childhood.

Appendix Table A5. OLS and Negative Binomial Regressions Predicting Children's Health

	Neonatal Risks		Asthma Diagnosis		Acute Conditions		Poor Health		Hospitalization	
	B	SE	B	SE	B	SE	B	SE	B	SE
Neonatal Risks			0.58	(0.14)**	0.06	(0.06)	0.54	(0.12)**	0.65	(0.15)**
ADHD Diagnosis	-		1.33	(0.46)**	0.16	(0.23)	0.02	(0.49)	0.79	(0.46)+
Autism Diagnosis	-		1.00	(0.70)	0.54	(0.31)+	1.42	(0.62)*	0.84	(0.70)
Multiple Birth	3.05	(0.10)**	-0.28	(0.15)+	0.01	(0.01)	-0.42	(0.13)*	-0.19	(0.16)
Child Age	-		0.02	(0.01)+	0.01	(0.01)	0.00	(0.01)	-0.02	(0.01)
Child Race										
Black	0.97	(0.14)**	0.56	(0.16)	-0.61	(0.07)**	0.06	(0.14)	0.03	(0.17)
Hispanic	0.30	(0.18)+	0.21	(0.19)	-0.25	(0.08)**	0.10	(0.16)	-0.08	(0.19)
Asian/PI	0.42	(0.22)+	0.33	(0.20)	-0.52	(0.09)**	0.13	(0.18)	-0.19	(0.23)
Multiracial	0.22	(0.22)	0.20	(0.25)	-0.22	(0.10)*	-0.25	(0.23)	-0.09	(0.27)
Child Gender	-0.29	(0.10)**	0.38	(0.11)**	0.18	(0.05)**	0.42	(0.09)**	0.34	(0.12)**
Household Income ($10k)	-		-0.00	(0.02)	0.01	(0.01)	-0.00	(0.02)	0.01	(0.02)
Maternal Education										
Less than High School	0.50	(0.15)**	-0.34	(0.18)+	-0.09	(0.08)	0.15	(0.15)	-0.07	(0.20)
High School/GED	0.35	(0.13)**	-0.25	(0.14)+	-0.20	(0.06)**	0.01	(0.12)	-0.24	(0.16)
College Degree	-0.03	(0.14)	0.00	(0.17)	-0.00	(0.07)	-0.04	(0.15)	0.27	(0.18)
Maternal Age	0.00	(0.01)	-0.01	(0.01)	-0.01	(0.00)	-0.01	(0.01)	-0.02	(0.01)*
Non-English Household	-0.36	(0.20)+	-0.23	(0.23)	-0.34	(0.09)**	0.77	(0.18)**	-0.24	(0.30)
Immigrant Household	-0.06	(0.16)	-0.16	(0.19)	-0.13	(0.07)+	0.27	(0.16)	-0.28	(0.25)
Marial Status										
Sometimes Married	-		0.04	(0.19)	0.05	(0.08)	-0.16	(0.16)	-0.06	(0.22)
Never Married	-		0.22	(0.16)	0.05	(0.07)	0.37	(0.13)**	0.25	(0.17)
Minors in Household	-		0.03	(0.05)	0.06	(0.02)**	0.14	(0.05)**	0.01	(0.06)
Child Health Insurance										
Always Public	-		0.16	(0.17)	0.08	(0.08)	0.11	(0.15)	0.36	(0.18)*
Unstable Arrangement	-		-0.34	(0.18)+	0.05	(0.07)	0.14	(0.15)	0.32	(0.19)+
Maternal Employment										
Sometimes Employed	-		0.16	(0.13)	-0.12	(0.05)*	-0.03	(0.11)	0.03	(0.14)
Never Employed	-		-0.28	(0.16)+	-0.28	(0.06)**	-0.19	(0.13)	-0.20	(0.16)
Public Assistance Receipt										
Always Received	-		0.76	(0.21)**	0.24	(0.09)**	0.36	(0.17)*	0.66	(0.21)**
Sometimes Received	-		0.43	(0.19)*	0.06	(0.08)	0.17	(0.16)	0.36	(0.18)*
Constant	-3.18	(0.30)**	-3.56	(0.80)**	1.16	(0.33)**	-2.23	(0.64)**	-0.84	(0.85)

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$ Neonatal risks, asthma diagnosis, poor health, and hospitalization were estimated using logistic regressions. Acute conditions were estimated using a negative binomial regression. All coefficients are untransformed.

APPENDIX B. EXPLORING ASSOCIATIONS BETWEEN ACUTE CONDITIONS AND TIME IN ECE

As previously described, models examining early learning opportunities as indirect pathways linking children's health conditions and school readiness skills revealed that the number of children's diagnosed acute conditions were positively associated with time in ECE. Time in ECE subsequently predicted greater math and reading skills and externalizing problems, functioning indirectly from more acute to higher pre-academic skills and behavior problems. Contrary to these results, the conceptual model tested in this study hypothesized that health problems would inhibit children's access to ECE or reduce the amount of time spent in ECE, in turn influencing school readiness skills. However, in regard to children's acute health conditions and exposure to ECE, a related body of research finds evidence for the opposite directionality of these associations (Augustine, Crosnoe, & Gordon, 2013; Gordon, Kaestner, & Korenman, 2007), revealing that participation in group- or center-based ECE is associated with increased acute conditions as a result of more widespread exposure to other children's illnesses. To further explore these conflicting hypotheses, an additional series of models were tested to help elucidate the direction of the associations linking children's acute conditions to their time in ECE. These models build on those establishing temporal precedence predicting time in ECE at Wave 3 from health indicators measured across Waves 1 and 2, which also revealed that the number of acute conditions experienced by age 2 predicted greater time in ECE at age 4.

First, models tested a series of propositions related to whether acute conditions explain variability in the amount of time children spend in ECE (Appendix Table B1).

These models examined the possibility that mothers of sick children may use more extensive child care either due to the increased difficulty of caring for sick children (Streisand, Braniecki, Tercyak, & Kazak, 2001), which may be proxied by measures of maternal functioning, or the need to work more to support the child's health care costs (Baker, 2002). The first set of models to test these hypotheses included an indicator of maternal psychological distress measured at Wave 3. Adding this covariate to the model did not reduce the size or significance of the association between acute conditions and time in ECE; additional analyses revealed that acute conditions predicted higher distress (results not shown), but distress was not associated with time in ECE, preventing indirect effects between acute conditions and time ECE from functioning through maternal psychological distress. A second set of models testing these hypotheses included a continuous measure of maternal work hours. Again, the addition of this covariate did not alter the relationship between acute conditions and time in ECE, and acute conditions did not predict more work hours (results not shown), though work hours predicted more time in ECE. Across these two models, results did not support hypotheses that heightened maternal stress or employment hours helped to explain this association.

A third hypothesis was that greater exposure to peers in ECE settings leads children to develop more acute conditions (Augustine, et al., 2013; Gordon et al., 2007). To first assess whether peer exposure confounds the link between acute conditions and time in ECE, the next set of models controlled for children's exposure to peers in all non-parental care experiences from infancy through childhood, using the average number of children in non-parental care settings across the first three waves of data (Appendix Table B1). The addition of this covariate decreased the size of the coefficient linking acute

conditions to children's ECE hours by 66% and reduced the coefficient to a non-significant level, suggesting that the association between acute conditions and time in ECE can be partially explained by the number of children that a child is exposed to in non-parental group or center care settings across the first four years of life.

Appendix Table B1. Path Analyses Controlling Maternal Distress, Maternal Work Hours, and Peer Exposure

	Predicting Mediators	
	Home Learning	Time in ECE
	B (SE)	B (SE)
Model 1: Controlling Parenting Stress		
Neonatal Risks	0.01 (0.02)	-0.03 (0.06)
Asthma Diagnosis	0.05 (0.02)+	0.14 (0.10)
Acute Conditions	0.00 (0.00)	0.03 (0.01)**
Poor Global Health	-0.06 (0.02)**	-0.02 (0.06)
Hospitalization	-0.02 (0.02)	-0.01 (0.09)
Maternal Psych. Distress	-0.01 (0.00)**	-0.01 (0.01)
Constant	0.44 (0.08)**	-0.95 (0.39)*
Model 2: Controlling Maternal Work Hours		
Neonatal Risks	0.01 (0.02)	-0.04 (0.06)
Asthma Diagnosis	0.05 (0.02)*	0.14 (0.10)
Acute Conditions	0.00 (0.00)	0.03 (0.01)**
Poor Global Health	-0.06 (0.02)**	-0.02 (0.06)
Hospitalization	-0.02 (0.02)	-0.02 (0.09)
Maternal Work Hours	-0.00 (0.00)**	0.02 (0.00)**
Constant	0.42 (0.08)**	-1.46 (0.39)**
Model 3: Controlling Peer Exposure		
Neonatal Risks	0.01 (0.02)	0.04 (0.06)
Asthma Diagnosis	0.05 (0.02)*	0.05 (0.10)
Acute Conditions	0.00 (0.00)	0.01 (0.01)
Poor Global Health	-0.06 (0.02)**	-0.03 (0.05)
Hospitalization	-0.02 (0.02)	0.02 (0.09)
Peer Exposure	0.00 (0.00)	0.14 (0.01)**
Constant	0.36 (0.08)**	-0.98 (0.33)**

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$ Covariates include ADHD and autism diagnosis, twin or triplet, child age, child gender, child race, months of kindergarten exposure, family income, maternal education, maternal age, non-English speaking household, immigrant household, marital status, minors in the household, child health insurance receipt, maternal employment, and public assistance receipt. Output from paths predicting school readiness outcomes not shown.

However, this finding indicates that the variance in time in ECE associated with peer exposure is also associated with acute conditions, but does not explain the directionality of these relations. In line with prior work (Augustine et al., 2013; Gordon et al., 2007), a more appropriate hypothesis is that a causal chain links time in ECE to acute conditions through greater child exposure. In order to test this hypothesis, a set of linear regression models using the normal theory approach to mediation was conducted (Hayes, 2013), in order to more clearly illuminate the pattern of associations. Linear regressions were employed due to convergence issues with count models, and all models were conducted in MPlus using the same analytic specifications as main models.

Three models were estimated in a series of steps: first, the average amount of time children spent in center care or ECE (Waves 1-3) predicted acute conditions; second, average time in ECE predicted the average number of peers that children were exposed to in nonparental care settings (Waves 1-3); third, average peer exposure was added to the model predicting the total number of acute conditions experienced from birth through age 4 (Waves 1-3) and Sobel tests for estimating the significance of the indirect effect were conducted (Appendix Table B2). Results found that each ten hours in ECE predicted 0.14 SDs higher acute conditions. Time in ECE also predicted exposure to 0.54 SDs more peers. When both of these variables were included in the model predicting acute conditions, the size of the coefficient for time in ECE was reduced by 20% to an effect size of 0.11 SDs, but remained statistically significant. A Sobel test revealed that a positive indirect effect from time in ECE to acute conditions through peer exposure partially explained this association ($z = 2.00$), providing some support for issues of

reverse causation in main models testing whether acute conditions are associated with more limited time in ECE.

Appendix Table B2. Results of Models to Test Indirect Effect Between Time in ECE and Acute Conditions Through Peer Exposure

	Model 1	Model 2	Model 3
	Acute Conditions	Peer Exposure	Acute Conditions
	B (SE)	B (SE)	B (SE)
Time in ECE	7.51 (1.34)**	39.46 (1.36)**	6.03 (1.77)**
Peer Exposure	-	-	0.04 (0.02)+
Constant	3.70 (1.26)**	1.94 (1.34)	3.59 (1.29)**

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$ Covariates include ADHD and autism diagnosis, twin or triplet, child age, child gender, child race, months of kindergarten exposure, family income, maternal education, maternal age, non-English speaking household, immigrant household, marital status, minors in the household, child health insurance receipt, maternal employment, and public assistance receipt. Output from paths predicting school readiness outcomes not shown.

To further illuminate potential bidirectionality and reverse causation effects between children's acute conditions and ECE participation, individual fixed effects analyses and cross-lagged path analyses were conducted. Two sets of individual fixed effects regression analyses were estimated, as shown in Appendix Table B3, one predicting time in ECE and the other predicting acute conditions, with time-varying independent variables of interest lagged to the prior wave. In the first model, acute conditions assessed at Wave 1 predicted time in ECE at Wave 2, and acute conditions at Wave 2 predicted time in ECE at Wave 3, controlling for all time-invariant characteristics as well as an array of time-varying covariates included in the models. Similar to the models establishing temporal precedence, these fixed effects analyses revealed that within individual children over time, early acute conditions continue to predict greater time in ECE at a later point in time. In contrast, more time in ECE predicted a lower rate of acute conditions at a later point in time, possibly reflecting evidence of immunity

effects, in which children's exposure to and experiences of early health problems strengthen their immune system and protect them from contracting infections at a later point in time (Holsapple et al., 2004).

Appendix Table B3. Individual Fixed Effects Regressions Predicting Time in ECE and Acute Conditions

	Time in ECE	Acute Conditions
	B (SE)	B (SE)
Lagged Acute Conditions	0.05 (0.01)**	-
Lagged Hours in ECE	-	-0.55 (0.27)*
Constant	-15.49 (0.43)**	2.64 (0.67)

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$ Cova riates include family income, maternal education, maternal age, marital status, minors in the household, child health insurance receipt, maternal employment, and public assistance receipt.

Finally, bidirectional cross-lagged path analyses were conducted to further explore the associations between acute conditions and time in ECE from infancy through early childhood (Appendix Table B4). In these models, acute conditions and time in ECE at each wave are used to predict each subsequent wave predicting both within and between constructs. A restricted set of covariates and only the base survey weight, W4R0, were used to predict each outcome and to facilitate model convergence, with time-varying covariates selected to coincide with the timing of each endogenous variables. Covariates included child race, child age, family income, maternal marital status, maternal employment, and public assistance receipt. Model fit was excellent, as evidenced by a χ^2 value of 66.49 (df = 33), RMSEA of 0.01 (CI = 0.01, 0.02), CFI and TLI values above 0.99 and an SRMR value below 0.01. Results showed that between infancy and toddlerhood, there were no bidirectional associations between acute conditions and time in ECE, but acute conditions in toddlerhood predicted greater time in

ECE in early childhood (0.20 SDs), even after controlling for the amount of time children spent in ECE in toddlerhood.

Appendix Table B4. Cross-Lagged Path Analyses Predicting Time in ECE and Acute Conditions

	Time in ECE_2	Acute $Conditions_2$	Time in ECE_3	Acute $Conditions_3$
	B (SE)	B (SE)	B (SE)	B (SE)
Time in ECE_1	1.30 (0.01)**	0.04 (0.07)	-	-
Acute $Conditions_1$	0.00 (0.00)	0.41 (0.04)**	-	-
Time in ECE_2	-	-	0.31 (0.04)**	-0.01 (0.06)
Acute $Conditions_2$	-	-	0.04 (0.01)**	0.38 (0.04)**
Constant	-0.01 (0.01)	-0.73 (0.58)	2.53 (0.34)**	-0.15 (0.76)

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$ Cova riates include child race, child age, family income, maternal education, maternal age, marital status, maternal employment, and public assistance receipt.

In short, results of these supplementary results consistently show that greater acute conditions predict more time in ECE across the first four years of children's lives. Although these supplementary analyses have not fully explained why associations between acute conditions and time in ECE emerge in an unexpected direction, these models help to illuminate some of the nuances in these associations. Clearly, additional empirical attention is needed to further elucidate the complex relationships between children's health and their experiences in non-parental care settings.