SHORT AND LONG-TERM EFFECTS OF BIRTH WEIGHT AND NEONATAL MEDICAL COMPLICATIONS ON CHILDREN'S EMOTIONAL AND BEHAVIORAL OUTCOMES

A Dissertation

presented to the Faculty of the Graduate School

University of Missouri-Columbia

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

By

NATALIE A. WILLIAMS, M.A.

Dr. Kristin A. Buss, Dissertation Supervisor

AUGUST 2008

The undersigned, appointed by the dean of the Graduate School, have examined the dissertation entitled

SHORT AND LONG-TERM EFFECTS OF BIRTH WEIGHT AND NEONATAL MEDICAL COMPLICATIONS ON CHILDREN'S EMOTIONAL AND BEHAVIORAL OUTCOMES

presented by Natalie A. Williams,

a candidate for the degree of Doctor of Philosophy,

and hereby certify that, in their opinion, it is worthy of acceptance.

Professor Kristin A. Buss

Professor Debora Bell

Professor Kenneth J. Sher

Professor Amanda Rose

Professor Janet E. Farmer

This dissertation is dedicated to the following people:

- to my husband, Dr. Gilbert R. Parra, who has shared the challenges involved in completing my doctoral work and whose loving support, feedback and insights have been invaluable throughout this process.

- to my father, Dr. David R. Williams, who has been my role-model for hard work, perseverance and personal sacrifice, and who inspires me to set high goals and gives me the confidence to achieve them.

- to my mother, M. Ann Williams, who is the strongest yet kindest woman I have ever known, and whose unwavering encouragement, patience, and faith in her children is the true meaning of love.

ACKNOWLEDGEMENTS

The efforts of many people have contributed to the completion of this dissertation. Kristin A. Buss, Ph.D., my primary advisor, was the most significant contributor. I thank her for her sustained interest in my graduate training and her thoughtful insights and feedback on this work. I gratefully acknowledge Janet E. Farmer, Ph.D., for her support in gaining access to use the Missouri Maternal and Infant Health Study (MMIHS) dataset and for her helpful feedback as a member of my dissertation committee. Other contributors included Debora Bell, Ph.D., Amanda Rose, Ph.D., and Kenneth J. Sher, Ph.D., who as members of my dissertation committee provided valuable direction and comments on this research. I acknowledge Drs. Linda Day and Laura Hillman for granting me permission to use the MMIHS data. The MMIHS was supported by the National Institute on Deafness and Other Communication Disorders through a contract with the Missouri Department of Health (N01-HD-6-2916). Finally, I thank the U.S. Department of Education, National Center for Educational Statistics for providing me with access to the Early Childhood Longitudinal Study – Birth Cohort dataset.

TABLE OF CONTENTS

LIST OF TABLES

Table Page

LIST OF FIGURES

Figure Page

SHORT AND LONG-TERM EFFECTS OF BIRTH WEIGHT AND NEONATAL MEDICAL COMPLICATIONS ON CHILDREN'S EMOTIONAL AND BEHAVIORAL OUTCOMES

Natalie A. Williams

Dr. Kristin A. Buss, Dissertation Supervisor

ABSTRACT

Research consistently indicates that children born low birth weight are at increased risk for poor adjustment outcomes throughout development. Despite a relatively large literature, the mechanisms accounting for the association between birth weight and adjustment are not well understood. The current investigation examined the effects of birth weight and neonatal medical complications on children's emotional and behavioral outcomes at age 2 (Study 1, $N = 9074$, 51.1% boys) and at age 10 (Study 2, $N = 771$, 48% boys). Although low birth weight was a significant predictor of toddler temperament characteristics (e.g., regulatory difficulties), it was a stronger negative influence on psychosocial functioning in late childhood. Importantly, the adverse effect of low birth weight on several of the age 10 outcomes was indirect through children's health status at birth. Specifically, the associations between birth weight and school-aged adjustment difficulties related to anxious/shy behavior, cognitive functioning/inattention, perfectionism, and social problems were mediated by neonatal medical complications.

INTRODUCTION

Low birth weight (LBW) is a costly public health problem with far-reaching consequences. Each year in the United States, approximately 12% of infants are born preterm (prior to the 37th week of gestation) and 8% of infants are born with low birth weights (<2,500 grams or 5.5 pounds; Hamilton, Martin, & Sutton, 2004). In 2003, hospital charges for all infants totaled $36.7 billion. Approximately half of that amount ($18.1 billion), was for babies with any diagnosis of prematurity or low birth weight (National Center for Health Statistics, 2004; see also Petrou, 2003). Although social policy interventions aimed at reducing some of the established risk factors for low birth weight appear to be effective[1], epidemiological data indicate that rates of premature birth and low birth weight continue to rise, up 16 and 13 percent respectively, since 1990 (Hamilton et al., 2004; Stevenson et al., 1998). This upswing in preterm birth and low birth weight is due to several factors, including growth in the number of multiple births and advances in neonatal medical care that have led to increased survival for infants born earlier and with extremely low birth weights (Alexander & Slay, 2002; Goldenberg & Rouse, 1998; Lumley, 2003).

Low birth weight has been found to negatively impact a wide range of developmental outcomes, with higher levels of neonatal and childhood morbidity noted in this population in terms of health, cognitive, and behavioral outcomes (for a review, see Taylor, Klein, & Hack, 2000). The adverse effects of low birth weight on children's cognitive and neurodevelopmental outcomes have been particularly well-documented, especially in those born with very low birth weight (<1,500 grams or 3.3 pounds) or extremely low birth weight (<750 grams or 1.5 pounds) (e.g., Hack & Fanaroff, 1999;

Vohr et al., 2000; Wallace & McCarton, 1997).[2] Comparatively less is known about the emotional and behavioral development of children born low birth weight. There is evidence that these children differ from their healthy full-term counterparts with respect to achieving early, normative developmental milestones (e.g., self-regulatory abilities), as well as both normative and psychopathology-based outcomes appearing later in development (e.g., social skills, internalizing and externalizing behavior problems). Closer examination of study findings, however, reveals considerable variability in the prevalence rates and the types of adjustment difficulties reported (e.g., Botting, Powls, Cooke, & Marlow, 1997; Breslau & Chilcoat, 2000; Elgen, Sommerfelt, & Markestad; 2002; Larroque, Tich, Guedeney, Marchand, & Burguet, 2005; Stevenson, Blackburn, & Pharoah, 1999; Szatmari, Saigal, Rosenbaum, Campbell, & King, 1990). These inconsistent results are due in part to recurrent methodological problems inherent in existing work, but also reflect a need to consider contextual and process factors that might explain why some children born low birth weight develop emotional and behavioral problems while others do not (Aylward, 2002; McCormick, 1997).

As the incidence of low birth weight continues to rise, there is a pressing need to resolve the mixed findings regarding the emotional and behavioral development for these children. By directly addressing the methodological and conceptual limitations of previous work, the present paper seeks to provide a more accurate characterization of the socioemotional adjustment of these children than is currently available. Literature reviewed for this investigation is divided into two major sections. First, studies linking birth weight to children's emotional and behavioral outcomes during two developmentally distinct age periods (i.e., infancy/toddlerhood and

childhood/adolescence) are reviewed. Second, neonatal medical complications and maternal psychological functioning are identified as potential influences on the relation between birth weight and children's adjustment. This discussion includes findings related to associations among birth weight, neonatal medical complications, and child adjustment, as well as a brief mention the potential interactive effect of maternal psychological functioning and neonatal medical complications in relation to child psychosocial outcomes. Specific aims of the current research are then delineated.

Emotional and Behavioral Adjustment in LBW Samples

Infancy and Toddlerhood

A growing literature documents an association between early-appearing individual differences in children's behavioral characteristics and later adjustment outcomes in normal populations. Initial work in this area focused on difficult temperament, which has been conceptualized as a constellation of behavioral characteristics including irregularity in biorhythms, high distractibility, negative affectivity, low adaptability, and high emotional intensity (e.g., Bates, 1980; Bates, Bayles, Bennet, Ridge, & Brown, 1991; Thomas & Chess, 1977; Rothbart & Bates, 1998). Findings from these studies suggest that children with difficult temperaments are at increased risk of developing emotional and behavioral adjustment difficulties during childhood and adolescence than children who are more easy going, especially in combination with other risk factors (e.g., harsh discipline or insensitive parental responding) (Bates, Wachs, & Emde, 1994; Belsky, Friedman, & Hsieh, 2001; Belsky, Hsieh, & Crnic, 1998; Guerin, Gottfried, & Thomas, 1997; Keenan, Shaw, Delliquadri, Giovannelli, & Walsh, 1998; Maziade, 1989; Rubin, Hastings, Chen, Stewart, &

McNichol, 1998). More recent work has examined links between specific behavioral features, such as negative emotionality or unadaptability, and a variety of adjustment outcomes (Calkins, Gill, Johnson, & Smith, 1999; Morris et al., 2002; Olson, Bates, Sandy, & Shilling, 2002; Prior, Smart, Sanson, & Oberklain, 2001). In this research, characteristics such as negative emotionality, resistance to control, unadaptability, and low persistence have been linked with later externalizing behavior problems (e.g., hyperactivity and disruptive behavior disorders; Eisenberg et al., 2005; Paterson & Sanson, 1999), whereas behavioral inhibition has been found associated with internalizing behavior problems (e.g., anxiety disorders; Arcus, 2001; Caspi, Henry, McGee, Moffitt, & Silva, 1995).

The associations reported between behavioral characteristics observed during infancy and toddlerhood (e.g., difficultness, low adaptability) and subsequent emotional and behavioral adjustment highlight the importance of early identification of children who may be at elevated risk for negative outcomes. Over the past decade, researchers examining the physiological bases of human behavior have identified specific brain regions important in the regulation of emotion and expression of behavior. The limbic structures (e.g., the amygdala) appear to serve a primary function in this regard, and are implicated in regulatory processes such as behavioral inhibition and approach, emotional reactivity, and sustained attention (Fox, Henderson, Marshall, Nichols, & Ghera, 2005; Lewis & Stieben, 2004; Posner & Petersen, 1990). Given that many of these structures do not become fully differentiated until the late in the third trimester of pregnancy (Fox, Henderson, & Marshall, 2001; Calkins & Fox, 1994; Halpern & Garcia Coll, 2000; Nelson, 1994; Rothbart, Derryberry, & Posner, 1994), children with a compromised

gestational course may be particularly likely to differ from normal birth weight, full-term children with respect to early behaviors and emotionality.

Although investigation of the relations between birth weight and children's early emotional and behavioral development is relatively limited, several studies comparing low birth weight infants with healthy term controls have reported significant group differences with respect to behavioral characteristics (Hawdon, Hey, Kolvin, & Fundudis, 1990; Hertzig & Mittelman, 1984; van-Beek, Hopkins, & Hoeksma, 1994). Studies focusing on aggregate measures of behavior report that infants and toddlers born with low birth weights are more likely to be rated as having difficult temperament than full-term controls (Chapieski & Evankovich, 1997; Gennaro, Tulman, & Fawcett, 1990; Medoff-Cooper, 1986). Illustratively, Weiss and colleagues examined relations between parent ratings of child difficultness and birth weight, and found that 80% of their sample of preterm, low birth weight infants could be classified as having difficult temperaments at 6 months of age (e.g., irregularity in biorhythms, highly distractible, and slow to adapt) (Weiss, St. Jonn-Seed, & Wilson, 2004). These findings are consistent with two previous studies finding similarly higher incidences of difficult temperament in infants with low birth weights (Genarro et al., 1990; Medoff-Cooper, 1986). Given that only 10-20% of children are classified as having difficult temperaments in full-term, normal birth weight samples, this represents a significant increase and suggests a link between birth weight and early behavioral development (Carey & McDevitt, 1995; Turecki, 1995).

Findings related to relations between birth weight and specific behavioral characteristics are less clear, although several studies report differences among children as a function of prematurity and low birth weight. In these studies, children born preterm

and/or with low birth weights have been found to be more intense in their emotional expression, more negative in mood, more avoidant and less responsive to their caregivers, and less adaptable to changes in their environment compared with their healthy full-term counterparts during the first year of life (Case-Smith, Butcher, & Reed, 1998; Garcia Coll, Halpern, Vohr, Seifer, & Oh, 1992; Langkamp, Kim, & Pascoe, 1998; Singer et al., 2003; Stiefel, Plunkett, & Meisels, 1987). Illustratively, one study examining temperament characteristics in a sample of preterm infants found that early in the first year (i.e., at 6 weeks and at 6 months) these infants were rated by their mothers as being less rhythmic, more difficult to soothe, lower on approach, more withdrawing, and less intense compared with standardized population-based norms (Hughes, Shultz, McGrath, & Medoff-Cooper, 1986). Many of these behavioral characteristics were found to diminish over time, such that the only significant difference remaining at 12 months was in behavioral persistence (i.e., they spent less time with an activity and were less likely to pursue the activity when faced with an obstacle to continued involvement) for a subset of the infants. Notably, the magnitude of reported group differences ranges across studies, and to date, there has not been a meta-analysis of studies examining relations between birth weight and children's early behavioral characteristics. In general, low to moderate effect sizes are typically reported in these studies with respect to most of these behavioral characteristics (i.e., effect sizes between .20 - .50). Thus, although differences between preterm and/or low birth weight infants and controls have been reported with respect to a range of behavioral characteristics during the first year of life, the magnitude of group differences is variable and observed differences may diminish over time for some outcomes.

In contrast, other studies find few or no differences between low birth weight infants and normal birth weight controls with respect to indices of early emotional and behavioral development during the first year and beyond (Goldstein & Bracey, 1988; Gorman, Lourie, & Choudhury, 2001; Halpern, Garcia Coll, Meyer, & Bendersky, 2001; Newman et al, 1997; Oberklaid, Sewell, Sanson, & Prior, 1991; Riese, 1994; Sajaniemi, Salokorpi, & von Wendt, 1998; Scher, Steppe & Banks, 1996; Robson & Cline, 1998; Watt, 1987). Honjo and colleagues compared low birth weight infants and full-term controls at 6 and 18 months on a range of behavioral characteristics, including activity level, rythmicity, adaptability, distractibility, approach versus withdrawal, and intensity (Honjo et al., 2002). In this study, the only significant difference that emerged between the groups was a higher score on the approach versus avoidance dimension at 18 months for the infants born with low birth weights (low birth weight infants being more avoidant than controls). Findings from a similar investigation also indicated no differences between low birth weight cases and normal birth weight controls with respect to emotional tone, social orientation, and activity level, but did find that infants born small-for-gestational-age were less attentive at 4 and 8 months than average-for-gestational-age controls (Halpern & Garcia Coll, 2000). However, by 12 months of age, this group difference in sustained attention was no longer significant. Notably, a few studies have actually found that low birth weight and preterm infants were classified as being *less* difficult than full-term, normal birth weight infants (Barrera, Rosenbaum, & Cunningham, 1987; Newman et al., 1997). For example, one study reported that at 24 months of age, infants born between 23 and 24 weeks of gestation were less active, more

adaptable, displayed more positive affect, and were less intense than the full-term controls (Sajaniemi et al.,1998).

In sum, preterm and/or low birth weight infants appear to differ from their healthy full-term counterparts during the first year of life with respect to a variety of emotional and behavioral characteristics. These infants have been variously described as less responsive, less adaptable, more avoidant, less persistent, and more negative in mood compared with normal populations; however, it is notable that other studies fail to find group differences with respect to behavior and emotional responding, or report that their preterm samples look better than term controls on behavioral indices. Untangling these discrepant findings requires consideration of several important issues. One issue relates to changes in the behavioral characteristics of preterm and/or low birth weight children over time. Although temperament characteristics are generally conceptualized as being relatively stable attributes in normal populations (Rothbart & Bates, 1998), several studies cited in the current review suggest that some of the early difficulties noted in preterm and/or low birth weight infants may diminish over time while others become increasing clinically meaningful. Unfortunately, few studies have examined group differences in these behaviors beyond the first year. A related issue pertains to differences among infants both within and across samples with respect to the extent of biological vulnerability. Specifically, the majority of studies in this area report findings based on samples consisting primarily of older preterm and heavier low birth weight infants (Taylor, Klein, & Hack, 2000). Further investigation of early outcomes in the most fragile infants (e.g., those born with birth weights less than 1500 grams) is needed to determine the nature of the relationship between birth weight and children's early

emotional and behavioral characteristics, as these children may be most likely to demonstrate persistent difficulties.

Mixed findings may also reflect differences across studies in the methodology used to assess children's emotional and behavioral characteristics. Indeed, it appears that significant associations between birth weight and children's outcomes are found more often in studies using observational measures of child behavior compared with those using parent-report measures. One possibility is that parent-report instruments and observational assessments tap different, yet equally valid, aspects of children's emotional and behavioral functioning (Rothbart and Bates, 1998). It is also possible, however, that parents of preterm/low birth weight infants are poor reporters of their children's behavioral difficulties, or have higher thresholds for tolerating their children's behavior problems. The issue of reporter bias for studies investigating emotional and behavioral adjustment in this population merits further consideration, and will be discussed in greater detail later in this paper (see *Summary and Limitations of Existing Studies*). Given these issues and the scarce literature in this area, additional research using both methods of assessment would provide a more complete view of the early adjustment of these children. Finally, it is possible that these mixed findings may reflect sample differences in contextual factors that have been found to influence children's early behavioral characteristics, such as aspects of the home environment or parental characteristics. Thus, investigation of possible mediating and moderating influences is an important next step for research examining early emotional and behavioral outcomes in low birth weight samples.

Childhood and Adolescence

A much larger literature has focused on the relation between birth weight and psychological outcomes during childhood and adolescence, with the majority of studies indicating that low birth weight is associated with poorer adjustment. Illustratively, a meta-analysis of studies conducted from 1980 to 2001 examining psychosocial adjustment outcomes in this population found higher rates of internalizing or externalizing problems in low birth weight samples in 13 of 16 studies included in the review, and associations between low birth weight and attention deficit hyperactivity disorder in 10 of 15 studies (Bhutta, et al., 2002). Studies consisting of cohorts born following the advent of neonatal technologies that have led to increased survival for more biologically immature infants report similar findings (Anderson & Doyle, 2003; Botting, et al., 1997; Breslau & Chilcoat, 2000; Brown, Kilbride, Turnbull, & Lemanek, 2003; Elgen, Sommerfelt, & Markestad; 2002; Favaro, Tenconi, & Santonastaso, 2006; Gardner et al., 2004; Horwood, Mogridge, & Darlow, 1998; Huddy, Johnson, & Hope, 2001; Nigg & Breslau, 2007; Reijneveld, de Kleine, van Baar, Kollee, Verhaak, Verhulst, et al., 2006; Saigal et al., 2003; Sommerfelt, Troland, Ellersten, & Markestad, 1996; Stevenson, Blackburn, & Pharoah, 1999; Sykes et al., 1997; Taylor, Klein, Minich, & Hack, 2000; Whitfield, Grunau, & Holsti, 1997). The most frequently cited group difference in these studies is a higher incidence of problems related to inattention, concentration, and hyperactivity in children born preterm and/or with low birth weight. Illustratively, one study examining associations between birth weight and attention-deficit hyperactivity disorder (ADHD) found that children with ADHD were three times more likely to have been born with birth weight less than 2,500 grams than non-ADHD controls (Mick,

Beiderman, Prince, Fischer, & Faraone, 2002). Because these authors controlled for potential confounders of the relation between ADHD and birth weight (i.e., prenatal exposure to alcohol and cigarettes, parental ADHD, parental intelligence, social class, and comorbid antisocial behavior problems in both parents and children), their findings suggest that low birth weight may be an independent risk factor for problems related to inattention and hyperactivity.

Associations between birth weight/gestational age and internalizing behavior problems have also been noted in this population, albeit less frequently (Costello, Worthman, Erkanli, & Angold, 2007; Gale & Martyn, 2004; Patton, Coffey, Carlin, Olsson, & Morley, 2004; Pharoah, Stevenson, Cooke, & Stevenson, 1994; Saigal et al., 2003; Thompson, Syddall, Rodin, Osmond, & Barker, 2001; Weisglas-Kuperus, Koot, Baerts, Fetter, & Sauer, 1993). For example, Botting et al. (1997) reported that at age 12, children born with born with very low birth weights demonstrated more symptoms of generalized anxiety disorder and depression compared with matched controls. Two other recent studies provide additional evidence for increased internalizing problems in this population. Indredavik and colleagues examined psychiatric symptoms and disorders during adolescence using standardized psychiatric assessments, and found that very low birth weight adolescents were at especially high risk for anxiety disorders (Indredavik et al., 2004). Likewise, Gardner and colleagues found higher rates of self-reported anxiety problems (e.g., nervousness, worries) in teenagers born prior to 29 weeks gestation compared with term controls, as well as higher rates of teacher and parent-reported depressive symptoms in the preterm sample (Gardner et al., 2004).

Fewer studies have examined more normative outcomes (e.g., social functioning

and adaptive behavior); however, there is some evidence that children born low birth weight also have increased difficulty with respect to these indices of adjustment (Dahl, Kaaresen, Tunby, Handegard, Kvernmo, & Ronning, 2007; Elgen, Sommerfelt, & Markestad, 2002; Gardner et al., 2004; Hoy et al., 1992; Schothorst, & van Engeland, 1996; Sommerfelt, et al., 1996; Taylor, Klein, Drotar, Schluchter, & Hack, 2006; Wocadlo & Reiger, 2006; Weindrich, Jennen-Steinmetz, Laucht, & Schmidt, 2003). Anderson and Doyle (2003) investigated emotional and behavioral outcomes at 8 years in a sample of infants born extremely low birth weight or very preterm and a matched control group comprised of full-term normal birth weight controls. In addition to showing more problems with attention and hyperactivity, children in the preterm/low birth weight group were rated by their parents and teachers as having fewer adaptive skills and less developed social and leadership skills. Social difficulties in children born very low birth weight were similarly noted in earlier work by Hoy and colleagues (Hoy et al., 1992). In this study, parent, peer, and child self-ratings indicated that these children were less socially mature and more isolated, withdrawn, and rejected by their peers than matched controls. These differences were found to persist across upper, middle, and lower social classes, and could not be explained by differences in child IQ.

Although there is consensus that children born with low birthweight are at elevated risk for psychosocial adjustment difficulties during childhood and adolescence, two issues complicate clear interpretation of these results. First, there is considerable variability across studies with respect to the rates of emotional and behavioral problems reported. For example, Elgen and colleagues examined risk for behavior problems in a population-based sample of children at age 11, and found that 40% of children born with

low birth weights demonstrated clinically-relevant emotional and behavioral problems (i.e., inattention, social difficulties, and anxiety/depression), compared with only 7% of normal birth weight controls (Elgen et al., 2002). Comparatively, Botting and colleagues reported on psychiatric outcomes in a sample of 12-year-old children born very low birth weight and matched controls, and found that 28% of very low birth weight children met criteria for at least one disorder, compared with only 9% of control children (Botting et al., 1997). Second, discrepant findings have been reported regarding the types of adjustment problems demonstrated by low birth weight children. Although an association between birth weight and problems related to attention and hyperactivity is a consistent finding in this literature, the effect of birth weight on other indices of adjustment is less clear. While a number of studies suggest that these children are also at risk for internalizing behavior problems, as well as problems with adaptive behavior and social functioning, not all investigations have found group differences with respect to these outcomes.

Inconsistencies related to the rates and types of problems reported during childhood and adolescence suggest several important avenues for future research. As with studies focusing on the relation of birth weight to infant/toddler outcomes, future work examining the effect of low birth weight on childhood adjustment would benefit by the inclusion of greater numbers of children born very low birth weight or extremely low birth weight in research samples, as these children may be most likely to demonstrate difficulties throughout childhood and into adolescence.

Three other issues relate to differences in the measurement of outcomes across studies. First, failure to use psychometrically sound measures of emotional and

behavioral functioning makes comparison across studies difficult, and may inaccurately represent the extent of adjustment difficulties in this population. Illustratively, studies using well-established measures of child behavior such as the Child Behavior Checklist (e.g., Botting et al., 1997; Breslau & Chilcoat, 2000; Stevenson et al., 1999) tend to find lower rates of emotional and behavioral difficulties in preterm/low birth weight samples compared with studies using semi-structured diagnostic interviews (e.g., Elgen et al., 2002). These findings suggest that researchers should use well-established measures whenever possible, as these measures would provide the most accurate assessment of child difficulties. Second, investigation of a wider range of outcomes, including an increased focus on internalizing problems and indices of social functioning (e.g., adaptive behavior, peer relations), could help clarify the risk for adjustment problems conferred by birth weight. Third, the issue of reporting bias again warrants consideration, as parents of children born preterm and/or low birth weight may be prone to over- or underestimate rates of problem behavior in their children. When possible, comparison of data from multiple informants would be particularly useful in addressing this issue; however, investigation of variables that have been found to affect the accuracy of parent reports would also be informative (e.g., maternal psychological distress). Relatedly, consideration of potential mediating and/or moderating factors that are likely to influence the emotional and behavioral trajectories of these infants remains an important direction for future work in this area (Aylward, 2002).

Summary and Limitations of Previous Studies

The current literature review suggests that children born low birth weight are at elevated risk for emotional and behavioral adjustment difficulties throughout

development. During infancy and toddlerhood, difficulties have been noted in this population with respect to both global measures of behavioral style (i.e., difficult temperament) and specific behavioral characteristics, including persistence, emotion regulation and expression, and adaptability. Subsequent problems with attention and hyperactivity are commonly noted throughout childhood and adolescence, and have been found in some investigations to be accompanied by internalizing symptomatology and deficits in social functioning. However, there is considerable heterogeneity among children born with LBW with respect to emotional and behavioral functioning during the first years of life. Additionally, studies exploring childhood and adolescent adjustment outcomes leave many questions unanswered regarding the longer term effects of low birth weight on children's adjustment, particularly with respect to the rates and types of problems noted in this population.

Potential sources of variability across existing studies are related to both methodological and conceptual issues, many of which have been described previously (i.e., concerns about sample selection and definition, variability in criteria used to assess adjustment and differences in how these outcomes are assessed across studies, and too short of an interval of follow-up for longitudinal studies). The possible confounding effect of reporter bias and the influence of mediating and/or moderating factors that may shape the emotional and behavioral trajectories of these infants now warrant consideration.

The role of reporting bias in studies examining children's emotional and behavioral has received a great deal of attention by researchers investigating discrepancies among informants in normal populations. In this literature, a robust finding

is that regardless of the method used to assess outcomes, different informants (i.e., children, parents, teachers, peers) rarely describe the same social, emotional and behavioral adjustment outcomes (for a review, see De Los Reyes & Kazdin, 2005). Indeed, studies consistently report low to moderate agreement among raters with respect to normative range outcomes, as well as clinically relevant externalizing and internalizing behavior problems (e.g., Frank, Van Egeren, Fortier, & Chase, 2000; Grills & Ollendick, 2002; Hay et al., 1999; Jensen et al., 1999). Researchers in this area acknowledge that various informants provide valuable information about different aspects of children's adjustment; however, they also suggest that informant reports can be biased by aspects of parent, child, and family functioning. Illustratively, positive associations have been reported between the extent of discrepancy among informant ratings of children's behavior and variables such as maternal psychological distress (e.g., depression, anxiety, stress), SES, and family characteristics (e.g., low parental acceptance, poor quality of parent-child interactions) (Briggs-Gowen et al., 1996; Chi & Hinshaw, 2002; Duhig et al., 2000; Kolko & Kazdin, 1993; Najman et al., 2000; Treutler & Epkins, 2003; Youngstrom et al., 2000).

Parents of children born low birth weight may be particularly likely to provide biased reports of their children's adjustment, given a) epidemiological data showing that preterm birth and low birth weight is disproportionately represented among members of socially and economically disadvantaged groups (Alexander & Slay, 2002; Kramer et al., 2001; National Center for Health Statistics, 2004; Paneth, 1995), and b) data indicating that preterm birth and low birth weight is often associated with higher rates of maternal psychological distress and poorer quality parent-child interaction across the first year of

life (e.g., Saigal, 1999; Singer et al., 2003; Thompson, Oehler, Catlett, & Johndrow, 1993; Tommiska, Ostberg, & Fellman, 2002). Moreover, it is possible that birth weight represents a child characteristic that has a more direct influence on parent reports of their children's behavior. In other words, parents may expect that their low birth weight infants will have more emotional and behavioral difficulties as a result of their compromised birth weight, and thus may be more likely to perceive adjustment difficulties even when they do not exist. Unfortunately, consideration of reporter bias in studies examining relations between birth weight and child adjustment outcomes is lacking. Future work in this area could address this issue by collecting data on children's emotional and behavioral outcomes from multiple informants.

Increased focus on the mechanisms through which birth weight affects outcomes could also greatly enhance our understanding of the relation between children's birth weight and subsequent emotional and behavioral adjustment outcomes. Often born at tremendous physical and social disadvantage, low birth weight children represent a unique at-risk population (Nadeau, Tessier, Boivin, Lefebvre & Robaey, 2001). Despite this, research suggests that not all of these children develop social and emotional adjustment problems. This finding underscores the inadequacy of linear cause-and-effect models for studies examining developmental outcomes in low birth weight populations, and highlights the need to consider mediating and moderating variables that may be particularly likely to affect the adjustment outcomes of this population. In an attempt to explain why some of children born low birth weight are found to have adjustment difficulties whereas others are indistinguishable from their full-term counterparts, the current studies examined how neonatal medical complications and maternal

psychological functioning affect the relation of birth weight to child socioemotional outcomes. Rationale for selecting these variables and existing literature related to the conditional indirect effects of these variables on children's outcomes are discussed below.

Potential Influences on Adjustment

Neonatal Medical Complications

During the neonatal period, children born with low birth weights are vulnerable to many serious medical complications, including sepsis, necrotizing enterocolitis, and respiratory problems such as chronic lung disease and bronchopulmonary dysplasia (Hack & Fanaroff, 1999; Shinwell, 2005; Walther, den Ouden, & Verloove-Vanhorick, 2000; Ward & Beachy, 2003). Neurological insults (e.g., periventricular hemorrhagic infarction (IVH), post-hemorrhagic hydrocephalus), are also quite common for these infants, with recent estimates suggesting that approximately 20% to 40% of infants born with low birth weights suffer IVH within the first 72 hours following delivery (Larroque et al., 2003; Wildrick, 1997). These medical problems represent major causes of death in this population, and are strongly associated with neuropsychological impairments in survivors (e.g., working memory delays, learning deficits, poorer expressive language skills, and less frequent social initiation) (Boyce, Smith, & Casto, 1999; Hughes et al., 1999; Korner, et al., 1993; Ment et al., 2003; Morris, Smith, Swank, Denson, & Landry, 2002; Sherlock, Anderson, & Doyle, 2005; Stoelhorst et al., 2003).

Since the early 1990s, the life-saving treatments for infants with these medical problems have included invasive physical interventions (e.g., repeated skin-breaking procedures) in combination with the use of pharmacological treatments (e.g., antibiotics,

antenatal and postnatal steroids to promote lung development, and surfactant) (Curley & Halliday, 2001; D'Angio & Maniscalco, 2004). Investigation into the effects of these newer methods of neonatal intensive care on infants' subsequent neurological and behavioral development is a relatively new research focus. However, initial findings from animal models suggest that stress and pain experienced during the neonatal period may have long-term effects on children's cognitive functioning and physiological reactivity (Anand, 2000; Emgard, Paradisi, Pirondi, Fernandez, Giardino, & Calza, 2006; Grunau, Holsti, & Peters, 2006; Grunau, 2002; Ladd et al., 2000; Pryce & Feldon, 2003; Ren et al., 2004). Illustratively, one recent study examining the effect of stress on the hypothalamic-pituitary-adrenal axis in preterm infants found that repeated neonatal procedural pain exposure was associated with a lower cortisol response to stress and a down-regulation of HPA activity (Grunau et al., 2005). These findings are concerning, as physiological changes in these systems may alter neurological functioning and relate to higher rates of behavioral problems (e.g., those related to individuals' self-regulation abilities) in later childhood (Grunau, 2003; Haley, Weinberg, & Grunau, 2006). Additionally, the long-term consequences of pharmacological agents that are commonly used to treat neonatal medical problems are unknown, but may have negative impact on children's emotional and behavioral adjustment. For example, there is now evidence that the corticosteroids commonly given to preterm neonates to treat lung disease are associated with poorer neuromotor and cognitive functioning at school-age (Jobe, 2004; Yeh et al., 2004).

Together, these data suggest that children who experience significant medical complications as a result of preterm birth or low birth weight may be at increased risk for

poorer emotional and behavioral adjustment outcomes for a variety of reasons (e.g., due to neuropsychological impairments associated with medical problems, or changes in biobehavioral systems resulting from stress or pharmacological agents). Indeed, studies that have examined associations among birth weight, neonatal medical history, and children's behavioral characteristics suggest that the poorer psychosocial outcomes noted in this population may be related to a history of medical complications during the neonatal period (Creasy, Jarvis, Myers, Markowitz, & Kerkering, 1993; De Groote, Roeyers, & Warreyn, 2007; Delobel-Ayoub et al., 2006; Garcia-Coll et al., 1988; Halpern, Brand, & Malone, 2001; Medoff-Cooper, 1986; Miceli et al., 2000; Myers, 1992; Raine, 2002; Whitaker et al., 1997). Illustratively, with respect to early-appearing differences Larroque and colleagues (Larroque et al., 2005) compared the temperamental characteristics of very preterm infants and their full-term counterparts, and found no significant group differences at 9 months of age with respect to parent-reported difficultness, unadaptability, or unpredictability. However, within the preterm group, infants with a history of neurological insults (e.g., cerebral lesions caused by IVH) were rated as lower on predictability and adaptability, and higher on the dull scale.

Other studies point to the effect of respiratory problems on the early behavioral characteristics of low birth weight infants. For example, Ross (1987) found no differences between low birth weight infants and term controls at 12 months of age on early behavioral characteristics, however, among the low birth weight infants those with a history of severe respiratory problems were more likely to be described by their caregivers as unadaptable. This association between early respiratory problems and characteristics consistent with aspects of difficult temperament has also been noted in

younger infants (Field, Hallock, Dempsey, & Shuman, 1978; Oberklaid, Prior, & Sanson, 1986; Spungen & Farran, 1986). Notably, another study examining individual differences in temperament (e.g., arousal, activity, and excitation management) among preterm infants found that differences between infants on these behavioral characteristics were not related to scores on a neonatal medical risk index (Korner, 1996). However, these findings are not consistent with the results of other studies using composite indices of medical risk, most likely due to the author's exclusion of infants with a history of serious medical problems (i.e., IVH, seizures, and some respiratory conditions).

Data also support an association between neonatal medical complications and emotional and behavioral adjustment during childhood and adolescence (Lindquist, Carlsson, Goran, Eva-Karin, & Uvebrant, 2006). Findings related to the effect of neonatal medical problems on school-aged adjustment outcomes are particularly well-illustrated by Taylor and colleagues in their ongoing longitudinal study examining the development of children with birth weights less than 750 grams, between 750 and 1,400 grams, and greater than 2,500 grams (Taylor, Klein, & Hack, 2000; Taylor, et al., 2000). In this study, results indicated that at all three assessment points (early school-age, middle school, and adolescence), children born with extremely low birth weight (i.e., less than 750 grams) demonstrated poorer psychosocial outcomes than both the very low birth weight children (i.e., between 750 and 1,400 grams) and the normal weight controls. However, neonatal medical complications, including chronic lung disease and cerebral ultrasonographic abnormalities, were found to account for a significant proportion of variance in behavioral outcomes for children involved in this study (Taylor, Klein, Schatschneider, & Hack, 1998). Relatedly, other studies suggest that observed group

differences may be due in part or entirely to the neurocognitive deficits that often result from neonatal medical problems common in children born at the extreme end of the low birth weight spectrum (Girouard et al., 1998; Whitaker et al., 1997). Illustratively, Nadeau and colleagues found that hyperactive and inattentive behavioral problems in children with low birth weight were fully mediated by working memory and intellectual delays respectively, whereas sensitive/isolated behaviors were explained by neuromotor delays (Nadeau, Tessier, Boivin, Lefebvre, & Robaey, 2003).

Maternal Psychological Functioning

The literature reviewed above suggests that a history of neonatal medical complications may help explain the association between birth weight and poorer child adjustment. It is possible, however, that the magnitude of this effect could vary as a function of individual difference or contextual factors. Consistent with this possibility, a relatively large body of evidence suggests that factors related to the family environment may interact with early biological risk factors to influence children's socioemotional, cognitive, and motor development (e.g., Bendersky & Lewis, 1994; Breslau, 1995; Breslau & Chilcoat, 2000; Landry, Smith, & Swank, 2003; Landry, Smith, Swank, Assel, & Vellet, 2001; Levy-Shiff et al., 1994; McGauhey, Starfield, Alexander, & Ensminger, 1991; Ross, Lipper, & Auld, 1990; Werner, Bierman, & French, 1971). One factor, however, that has not received a great deal of attention in terms of moderating the relation between early biological risk and children's emotional and behavioral outcomes is maternal psychological distress. This is a particularly notable limitation, given that the detrimental effects of psychological problems (e.g., depressive symptomatology) on child adjustment in normal populations have been well-documented.

During infancy and early toddlerhood, full-term normal birth weight children of depressed mothers are rated as more irritable and withdrawn, and have also been found to display more negative and less positive affect, vocalize less, and be rated as less active during interactions with caregivers compared with children of non-depressed mothers (e.g., Cicchetti, Rogosch, & Toth, 1998; Downey & Coyne, 1990; Field, 1995; NICHD Early Child Care Research Network, 1999; Singer et al., 1997). Increased rates of a variety of emotional and behavioral problems in children of mothers with psychological difficulties during later childhood have also been reported (e.g., Elgar, Curtis, McGrath, Waschbusch, & Stewart, 2003; Gefland, Teti, & Douglas, 1990; Lee, & Gotlib, 1991). Illustratively, Bennett and colleagues examined the influence of variety of risk factors on children's intellectual and socioemotional adjustment at age 4, including prenatal substance exposure, environmental risk, harsh parenting, and maternal depression. Findings indicated that maternal depression was the strongest predictor of child internalizing difficulties, but also emerged as a significant predictor of externalizing behavior problems (Bennett, Bendersky, & Lewis, 2002).

It seems particularly important to consider maternal psychological functioning in caregivers of infants born low birth weight, given that having a medically fragile infant may increase the likelihood of maternal distress. Indeed, studies suggest that compared with mothers of healthy term-born infants, mothers of preterm and low birth weight infants demonstrate higher levels of psychological distress both prior to giving birth and in the months following birth (Brooten, Gennaro, & Brown, 1988; Cronin, Shapiro, Casiro, & Cheang, 1995; Drewett, Blair, Emmett, & Emond, 2004; Gennaro, 1988; Pederson, Bento, Chance, Evans, & Fox, 1987; Miles, Holditch-Davis, Schwartz, &

Scher, 2007; Saigal, 1999; Singer et al., 2003; Thompson, Oehler, Catlett, & Johndrow, 1993; Tommiska, Ostberg, & Fellman, 2005). Symptoms of depression have been found to be especially prominent in this population during the 12 months postpartum, and are reportedly more common in mothers of both low- and high-risk low birth weight infants compared with mothers of term infants irrespective of maternal age, race, marital status, educational level, and socioeconomic status (Singer, et al., 1999). Together with the consistent associations reported between maternal depression and child negative adjustment in normal populations, these findings underscore the importance of examining how maternal depression affects the relation between neonatal medical complications and children's emotional and behavioral adjustment outcomes. It is possible that the increased risk for poorer adjustment that is associated with neonatal medical complications may be heightened in combination with maternal depression, putting these children at even greater risk for negative outcomes.

Summary

The current literature review suggests that consideration of both neonatal medical complications and maternal psychological functioning may help explain the mixed evidence regarding the association of low birth weight to early, normative developmental outcomes (e.g., temperament characteristics), as well as to normative and clinically relevant outcomes appearing later in development. A history of neonatal medical complications at birth (e.g., IVH, respiratory problems) has been found to be an important factor in the association between birth weight and children's adjustment outcomes. Importantly, this process may not be the same in all children or in all contexts. Given established associations between maternal psychological problems and poorer

child adjustment in normal populations, it is possible that maternal distress may attenuate or temper the adverse effects of neonatal medical complications on children's emotional and behavioral adjustment. The possible mediating (in the case of neonatal medical complications) and moderating (in the case of maternal distress) effects of these variables highlight the limitations of traditional linear cause-and-effect models for studies examining developmental outcomes in low birth weight populations, and suggest that failing to account for these influences may result in an inaccurate representation of the psychosocial risks associated with low birth weight.

Aim of the Current Studies

The current studies address issues highlighted in the previous discussion and were designed with the overarching goal of better understanding the mechanisms through which compromised birth weight affects children's emotional and behavioral adjustment outcomes. Both studies had the same two objectives. Our primary objective was to test possible mediational links between birth weight, neonatal medical complications, and indices of child adjustment (Figure 1). Specifically, we were interested in the extent to which neonatal medical complications mediated the relation of birth weight to children's emotional and behavioral adjustment outcomes. Consistent with previous work in this area, we hypothesized that the higher rates of adjustment difficulties found in children with lower birth weights and/or gestational age can be attributed, at least in part, to a history of medical complications during the neonatal period.

Our secondary objective was to examine whether the mediating effect of neonatal medical complications on the relation of birth weight to child outcomes depended on maternal psychological functioning. From both a theoretical and empirical perspective,

this study goal may be conceptualized in terms of a moderated mediation process (James & Brett, 1984; Muller et al., 2005). Moderated mediation occurs when the mediating process that is responsible for producing the effect of the predictor variable on the criterion variable is dependent on the value of the moderating variable (Baron & Kenny, 1986; James & Brett, 1984; Muller, Judd, & Yzerbyt, 2005). Figure 2 depicts the primary hypothesized moderated mediation framework that was investigated in the current studies. We anticipated that the mediating effect of neonatal medical complications on children's adjustment outcomes would be stronger under the condition of a higher level of maternal psychological distress, but have less of a negative impact on adjustment outcomes when mothers reported lower levels of distress.

Study 1

Method

Participants

Data for Study 1 were drawn from the Early Childhood Longitudinal Study-Birth Cohort (ECLS-B), an ongoing national longitudinal study focusing on characteristics of children and their families that are hypothesized to affect children's first experiences in formal schooling. This project is conducted by the National Center for Education Statistics (NCES is a division of the Institute of Educational Sciences in the U.S. Department of Education) in collaboration with several health, education, and human services agencies (e.g., NICHD, the CDC, the Maternal and Child Health Bureau, NIMH, Office of Minority Health). The ECLS-B data and codebooks are made available for investigators interested in a broad range of issues related to child health and development.

ECLS-B participants were first assessed between 2001 and 2002 when the target

children were 9-months-old, then again in 2003, when they were approximately 2-years-old. Potential participants for this study were identified using birth certificate data provided by the National Center for Health Statistics. Families identified through the sampling procedure were excluded from the final sample if the target child had died or had been adopted after the issuance of the birth certificate, or if the child's mother was younger than 15 years of age at the time of the target child's birth. Asian children, Pacific Islander children, Chinese children, twins, moderately low birth weight, and very low birth weight children were intentionally oversampled. Consequently, the ECLS-B study population may be slightly skewed from the population norms of the United States.

To correct for oversampling and allow for population generalizability, design (base) weighting was created by NCES. Fourteen design weights are included in the ECLS-B 9-month and 2-year dataset. Of the available design weights, the most appropriate weight for an analysis depends on the source of the data (e.g., parent interview data, child assessment data, combination of parent interview and child assessment data) and wave of data collection (9-month or 2-year) from which the variables used in an analysis are drawn. Thus, because analysis of demographic profiles for the current study were completed using child and mother characteristics obtained through birth certificates and the 9-month parent interviews, we weighted our estimates using the 9-month parent interview and birth certificate data base weight to produce the population weighted percentages for each demographic characteristic. Note that weighting was also utilized in the current study in order to maintain the ability to ascribe findings to a nationally representative population. To this end, our analyses employed three degrees of weighting: design weights, population-sampling unit weights (PSU's),

and post-stratification weights (strata).

Of the 13,500 potential participants identified through birth certificates, 10,688 families provided data at 9-months for an overall response rate of 74.1 percent. The resulting sample was nationally representative with regards to demographics and family characteristics, and included 641 children born with birth weights between 1500-2500 grams (LBW) and 106 children born with birth weights less than 1500 grams (VLBW). For the 2 year assessment, efforts were made to follow-up as many of the original families as possible, and 9,835 children and their parents participated in the second wave of data collection. As noted previously, twins were oversampled in the ECLS-B study. Consequently, the 9-month ECLS-B data file included 810 twin pairs for which data was available on both children. To maintain the independence of the data in the present study, we randomly selected one child from each of these twin cases, resulting in a total sample of 9,878 families who participated in the 9-month data collection. The analytic sample for the current study was drawn from this group, and included all families who participated in the second wave of data collection (N = 9074). Demographic characteristics of our sample are presented in Table 1.

Attrition analyses suggest that our follow-up sample differed from the original ECLS-B sample on several demographic variables. Specifically, this sample included significantly more Caucasian and fewer Hispanic children than would be expected by chance (χ^2 (3, N = 9840) = 46.56, $p < .0001$). Group differences were also found in maternal educational attainment and marital status, with participants in the follow-up sample being more educated (χ^2 (3, N = 9816) = 69.43, $p < .0001$) and less likely to be married (χ^2 (1, N = 9864) = 20.72, $p < .0001$) than those who provided data only at

baseline. Children who were and were not followed up did not differ with respect to biological sex, birth weight, or prenatal cigarette exposure.

Procedure

Sources of data for the ECLS-B include face-to-face interviews, self-report questionnaires, and in-home direct observations. Baseline data collection occurred between the fall of 2001 and the fall of 2002, when the target children were approximately 9 months of age. At that time, trained interviewers visited families in their homes and conducted a computer-based structured interview with the target child's primary caregiver (typically the child's mother or female guardian), which took approximately 60 minutes to complete. Fathers completed a self-administered questionnaire assessing the role they play in the development of their children, and child participants were engaged in activities designed to measure important developmental skills in the cognitive, social, emotional, and physical domains. Note that father data was not used in the current study, as fathers were not asked to report on their children's emotional and behavioral characteristics. Interviewers also observed and documented interactions between children and their caregivers. Spanish versions of the questionnaires were provided in cases where the primary language spoken at home was not English, and bilingual interviewers were used when necessary.

Similar data collection procedures were followed for the second wave of data collection, which occurred during 2003 when the target children were approximately 2-years-old. One additional aspect of this follow-up assessment included gathering questionnaire data from childcare providers regarding aspects of the childcare environment. As noted previously, the ECLS-B is an ongoing longitudinal study. Future

data collections are planned for when children are approximately one year away from entering kindergarten, during the kindergarten year, and finally during the first grade; however, these data were not available for inclusion in the current study.

Measures

Demographics. Variables that may influence outcomes for children born low birth weight, but were not the primary focus of the current investigation, were included as covariates in the current study. These included four demographic characteristics (i.e., child sex, race/ethnicity, maternal marital status, and maternal education level) and one prenatal factor (i.e., maternal smoking during pregnancy). Child sex and race/ethnicity data were obtained from the child's birth certificates and confirmed during parent interviews. Measurement of race/ethnicity in the ECLS-B included six categories (White, not-Hispanic, Black or African American, non-Hispanic, Hispanic or Latino/a, Asian American/Hawaiian/Pacific Islander, American Indian or Alaska native, and Multiracial, non-Hispanic). Given the small number of subjects in some of these groups, for the present study groups have been collapsed into four race/ethnicity categories, with 1 = White, Non-Hispanic, 2 = Black or African American, Non-Hispanic, 3 = Hispanic, and 4 = other racial or ethnic minority. For all analyses, dummy-coding of the race/ethnicity variable uses the White, non-Hispanic group as the reference group.

Information regarding maternal marital status, maternal education level, and smoking during pregnancy was drawn from the 9-month parent-interview. For the current study, marital status is coded as a two level variable (1 = married and 2 = not married), while maternal education level is coded as a four level variable (1 = less than high school education, 2 = high school diploma or equalivent, 3 = some college or college degree, 4 =

postgraduate education). Finally, prenatal cigarette exposure was included as a covariate in the present study due to growing evidence supporting links between prenatal exposure to cigarette smoking and later disruptive behavior disorders (e.g., attention-deficit hyperactivity disorder (ADHD), conduct disorder) (Breslau & Chilcoat, 2000; Linnet et al., 2003). Prenatal cigarette exposure was determined based on mothers' responses to a question included in the 9-month maternal interview about their smoking behavior during the third trimester of their pregnancy. For the current study, this variable was dichotomized, with 0 = no cigarette exposure during the last trimester and 1 = cigarette exposure during the last trimester.

Birth weight. Infant birth certificate records provided data regarding children's birth weight. Weight was measured in grams.

Maternal psychological functioning. Maternal depressive symptomatology was assessed when children were 9-months-old. The severity of maternal depression was determined based on mothers' responses to a question included in the parent interview asking them to indicate how often during the previous week they experienced 12 symptoms consistent with depression (0 = rarely or never, 1 = some or a little, 2 = occasionally or moderate, 3 = most or all of the time). Items included in this question were drawn from the well-validated Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977, 1991), and tapped feelings and behaviors related to eating/appetite, feeling that everything was an effort, difficulty sleeping, trouble concentrating, and feeling sad, lonely, or depressed. The total score for this question was calculated by summing the individual's responses to each item, so that a higher score indicated more severe depressive symptomatology. For individuals who provided three or

more invalid responses (refused or missing), the CES-D score was coded as missing. Consistent with internal reliability estimates typically reported for the CES-D (0.8 to 0.9) (Radloff, 1977, 1991), this measure of maternal depression demonstrated excellent internal reliability in the current sample ($\alpha = .89$). Published reports also show test-retest reliability estimates to be acceptable (0.4 to 0.7).

Neonatal medical complications. Consistent with previous work in this area (e.g., Girouard et al., 1998; Miceli et al., 2000; Miller, Bowen, Gibson, Hand, & Ungerer, 2001), a composite measure reflecting the extent of infant medical complications at birth was created using information from the infants' birth certificates and the 9-month parent self-administered questionnaires. Items for this composite index were selected based on their reliability and clinical relevance. Specifically, items either directly assessed diagnosed medical problems that were associated with preterm birth and low birth weight (e.g., respiratory distress syndrome), or reflected treatment for medical problems (e.g., number of days hospitalized following birth, need for ventilator support) (e.g., Ward & Beachy, 2003). The neonatal medical complications index included the following variables: a) 5-minute APGAR score (ranged from 0 to 10, reverse scored so that a higher score indicated greater need for resuscitative measures following delivery), b) length of stay in the hospital following birth (1 = 1 day or less, 2 = 2-3 days, 3 = 4-7 days, 4 = 8 to 13 days, 5 = 2 to 4 weeks, 6 = more than 4 weeks), c) child required ventilator support at birth for greater than 30 minutes (0 = no, 1 = yes), d) infant diagnosed with hyaline membrane disease (i.e., respiratory distress syndrome) (0 = no, 1 = yes), e) infant experienced seizures following delivery (0 = no, 1 = yes), d) infant diagnosed with hydrocephalus (0 = no, 1 = yes), e) infant had central nervous system conditions

following delivery (e.g., IVH) (0 = no, 1 = yes), and infant had circulatory problems following delivery (0 = no, 1 = yes).

To create the composite measure, participant responses for the six dichotomous constituent variables were summed to create a new variable ranging from 0 to 6. Bivariate correlations between this variable and the two remaining indictors of neonatal medical complications (i.e., 5-minute APGAR score, length of time spent in the hospital following birth) were significant ($r = .47$, $p < .0001$ and $r = .70$, $p < .0001$, respectively). Infants' 5-minute APGAR score (reverse-scored) and length of time spent in the hospital following birth were also significantly associated ($r = .45$, $p < .0001$). Thus, the composite measure indexing the extent of neonatal medical complications at birth was computed as the mean of the standardized (0, 1) three constituent scores. This measure demonstrated good internal reliability ($\alpha = .78$).

Emotional and behavioral adjustment. Typical-range indicators of children's emotional and behavioral adjustment at age 2 were assessed using information drawn from the direct child observations made during the 2-year follow-up home visit, and from mothers' responses to interview questions focusing on aspects of children's temperament. Direct assessments of child negative or positive affect (e.g., smiling, fussing), adaptability (e.g., relinquishing items willingly), and social engagement were determined based on interviewers' responses to eleven items from the Behavior Rating Scale of the Bayley Short Form – Research Edition (BSID-II; Bayley, 1993). Interviewers who had received extensive training on observing and coding child behavior using videotapes rated each of the eleven specific child behaviors based on their observations during the series of direct child assessments conducted in the child's home using a 5-point scale

(e.g., for the attention item, 1 = constantly off task, does not attend, 2 = typically off task, attends in 1 or 2 instances, 3 = off task half the time, 4 = typically attends, attention wanders in 1 or 2 instances, 5 = constantly attends). Specific behaviors rated by the interviewers included a) child displays positive affect, b) child displays negative affect, c) child adapts to change in materials, d) child shows interest in materials, e) child pays attention to tasks, f) child persistent is tasks, g) child displays fearfulness in tasks, h) child displays frustration in tasks, i) child displays social engagement, and j) child displays cooperation. One additional item asked interviewers to rate children's motor control, and was not included in the analyses described below.

A principle components analysis of the behavior ratings indicated a two factor solution. The first component captured positive affect/sociable (items a, g, i), and the second captured negative affect/low engagement (items b, c, d, e, f, h, j). For the current study, we used two composites created to represent these components (i.e., positive affect/sociable and negative affect/low engagement). The seven constituent items for the negative affect/low engagement composite were reverse-scored prior to creating the composite so that higher scores indicated more negative affect/lower engagement. Each composite was then computed as the sum of the scores for the appropriate constituent items. Both measures demonstrated good internal reliability (positive affect/sociable α = .78, negative affect/low engagement α = .91).

Indirect assessments of children's behavioral characteristics at age 2 were obtained from the child primary caregiver during the parent interview at the second wave of data collection. A subset of questions tapping maternal perceptions of their children's early behavioral characteristics was drawn from the Infant/Toddler Symptom Checklist

(ITSC; DeGangi, Poisson, Sickel, & Wiener, 1995). The full 19-item ITSC is a screening instrument designed to identify infants and toddlers ages 7 to 30 months with regulatory disorders, and focuses on infant behaviors in the domains of self-regulation, attention, sleep, feeding, sensitivity to tactile stimulation, tolerance of movement, sensitivity to auditory and visual stimulation, and socioemotional functioning. This assessment tool was validated using two samples of infants 7 to 30 months of age (154 normal infants and 67 regulatory-disordered infants). Results of psychometric testing indicated a false positive error rate of 3-13% and false negative error rate of 0-14% across the age ranges.

For the purpose of the ECLS-B, a subset of 8-items was selected from this measure on the basis of the items' content and ability to identify children with regulatory difficulties. Selected items successfully differentiated (on the basis of the t-tests presented in the ITSC manual) children with regulatory problems and those without regulatory problems. Primary caregivers were asked to rate their child's behavior with respect to the following behavioral domains using a 4-point scale (0 = never, 1 = used to be, 2 = sometimes, 3 = most times): a) fussy or irritable, b) goes from whimper to crying, c) unable to wait without crying, d) easily distractible, e) needs help to fall asleep, f) tunes out from activity, and g) can't shift focus easily. One addition item asked caregivers to indicate how difficult their child is to raise on average using a scale that ranges from 0 to 5 (1 = not at all difficult, 2 = not very difficult, 3 = about average, 4 = somewhat difficult, 5 = very difficult). Although ITSC items are presented in conceptual categories, there is one factor that corresponds to infants' self-regulation. Thus, the ITSC total score was obtained by summing (standardized) item responses, so that a higher score indicated

more self-regulatory difficulties. Cronbach's alpha for this measure in the current sample was adequate and suggests that all items form a single scale ($\alpha = .70$).

Results

Descriptive Associations Among Study Variables

Table 2 summarizes the means, standard deviations, and zero-order correlations among study control, predictor, and criterion variables. Consistent with previous findings, prenatal cigarette exposure was associated with lower birth weight, and lower birth weight was associated with more severe medical complications at birth. Lower infant birth weight and more severe medical complications were also related to single parenthood, lower maternal educational attainment, increased maternal depressive symptomatology, and poorer outcomes with respect to all three of the emotional and behavioral characteristics at age 2 (see Table 2). Regarding the latter, significant associations were also noted between children's early behavioral characteristics and several of the demographic and contextual variables. Specifically, increased regulatory difficulties, lower positive affect/sociable scores and higher negative affect/low engagement scores were related to male gender, single parenthood, and maternal depression scores.

Significant differences among race/ethnicity groups were found with respect to several of the key study variables. Caucasian babies had higher birth weights and African American/Black babies had lower birth weights compared with all the other groups (i.e., Hispanic, other Racial/Ethnic minority). African American babies also had more neonatal medical complications at birth compared with the other racial groups, and African American mothers had higher depression scores than mothers in the other groups.

Differences were also found with respect to the emotional and behavioral outcomes. Specifically, Caucasian children demonstrated fewer regulatory difficulties compared with all other racial groups, and African American children had more regulatory difficulties than both Hispanic and other minority children. No difference were found between Caucasian and African American children in terms of Positive Affect/Sociability, however, children in both of these groups demonstrated more PA/Sociable than Hispanic and other minority children. Caucasian children had the lowest Negative Affect/Low Engagement scores compared with all other groups, however, no other differences were noted between the groups.

Mediating Effects of Neonatal Medical Complications

Procedures for testing mediation as outlined by Baron and Kenny (1986) were followed to test our hypotheses related to the mediating role of neonatal medical complications. A series of three regression models were conducted to examine whether neonatal medical complications mediated the relation between birth weight and children's early behavioral characteristics. The first step in this mediation framework involved examining the association between children's birth weight and their behavioral characteristics at age two and the five control variables (child biological sex, race/ethnicity, maternal marital status, maternal educational attainment, and prenatal cigarette exposure). Results of these analyses are summarized in Table 3. After statistically controlling for the five covariates, birth weight significantly predicted children's regulatory difficulties, positive affect/sociable, and negative affect/low engagement scores. Specifically, children born with lower birth weights demonstrated increased regulatory difficulties, and demonstrated less positive affect/sociability and

more negative affect/low engagement. These findings satisfy the first condition necessary to establish mediation (i.e., the predictor must be significantly related to the criterion).

Our second series of regression analyses involved predicting neonatal medical complications as a function of birth weight and the five control variables. Key findings showing that neonatal medical complications continued to be significantly related to birth weight after the effects of the covariates were taken into account are presented in Table 3. In addition, results of this regression analysis suggested that male infants experienced more severe medical complications at birth, and Caucasian infants had more severe medical complications compared with both Hispanic and other minority infants. Prenatal cigarette exposure, maternal educational attainment, and mothers' marital status were unrelated to infant neonatal medical complications.

Birth weight and neonatal medical complications were included as predictors of child adjustment in a final series of regression models to test whether the third condition required for testing mediation was met. The third mediation criterion is that the mediator must significantly affect the dependent variable. In the current study, no association was found between neonatal medical complications and children's regulatory difficulties or positive affect/sociability. Thus, the third condition was not met for these outcomes and they were not examined in subsequent models testing for mediation. However, significant positive associations were observed between neonatal medical complications and children's negative affect/low engagement scores.

Because (a) birth weight predicted neonatal medical complications ($\beta = -.39$, $p < .01$), (b) birth weight predicted children's negative affect/low engagement scores ($\beta = -.07$, $p < .01$), and (c) neonatal medical complications also predicted children's negative

affect/low engagement scores ($\beta = .03$, $p < .05$), the initial conditions for a mediator model were met for this outcome. We tested the fourth condition necessary to establish mediation by examining whether after controlling for the effect of neonatal medical complications, the significant effect of birth weight on children's negative affect/low engagement scores was eliminated or significantly reduced. Our regression model testing this question revealed that birth weight continued to be a significant predictor of children's negative affect/low engagement scores ($\beta = -.06$, $p < .001$); however, significance testing of this difference using a Sobel test (Sobel, 1988) showed that the decrement in prediction was statistically significant (Sobel test = -2.02, $p < .05$).

Maternal Psychological Functioning as a Moderator

The second objective of the current study was to examine whether the mediating effect of neonatal medical complications on the relation of birth weight to child outcomes depended on maternal psychological functioning. Because evidence for a mediating effect of neonatal medical complications was found for children's negative affect/low engagement scores, moderated mediation analyses were conducted for this outcome. The final regression model establishing partial mediation for this criterion variable was used as the foundation for testing moderated mediation. Specifically, birth weight and neonatal medical complications were included as predictors of each child adjustment variable, along with the same covariates used previously. Maternal depression scores and the interaction between depression scores and neonatal medical complications were added to the mediation regression model to test moderated mediation as hypothesized in Figure 2. Results of these analyses did not provide support for the model of moderated mediation as hypothesized.

Testing Alternative Mediated Moderation Models

Although the moderated mediation framework investigated above was consistent with extant theory and research concerning relations among birth weight, neonatal medical complications, child adjustment outcomes, and maternal psychological functioning, alternative moderated mediation models have been developed (for an overview, see James & Brett, 1984; Muller et al., 2005; Preacher, Rucker, & Hayes, 2005). In an attempt to better understand the complex relations among primary study variables, a series of exploratory analyses designed to investigate other possible moderated mediation frameworks were conducted. First, we tested an alternative model in which maternal psychological functioning moderates the relation between birth weight and neonatal medical complications (Figure 3; bold paths represent the model under consideration). This model was examined statistically by testing a regression equation predicting neonatal medical complications from the five covariates, birth weight, maternal psychological distress, and the interaction between birth weight and maternal psychological distress. Findings from this analysis indicted the presence of a small but significant interaction effect ($\beta = -.03$, $p < .01$) (Aiken & West, 1991). Specifically, for children born with lower birth weights, more severe maternal depression was related to increased infant medical complications following birth (Figure 4). However, for children born at higher birth weights, maternal depression did not impact the severity of medical complications.

Another potential moderated mediation framework is a model in which maternal depression moderates the relation of birth weight to child adjustment outcomes, independent of the effect of neonatal medical complications (Figure 5). To examine this

possibility, we conducted a series of regression analyses predicting children's negative affect/low engagement scores from the five control variables, birth weight, maternal depression, and the interaction between birth weight and depression scores. Results of these analyses showed that although maternal depression predicted negative affect/low engagement scores ($\beta = .04$, $p < .10$), the relation of birth weight to negative affect/low engagement was not moderated by maternal depression.

Finally, it is possible that maternal psychological functioning moderates both the indirect effect of neonatal medical complications on child adjustment, and the residual effect of birth weight on children's adjustment outcomes (after controlling for neonatal medical complications) (Figure 6). To explore this possibility, we tested a regression model predicting children's negative affect/low engagement scores from the control variables, birth weight, maternal depression, the interaction between birth weight and depression scores, neonatal medical complications, and the interaction between neonatal medical complications and maternal depression. Results of these analyses did not provide support for the model of moderated mediation depicted in Figure 5.

Study 2

Method

Participants

Data for Study 2 were obtained from the Missouri Maternal and Infant Health Study (MMIHS) (Missouri Department of Health State Center for Health Statistics, 1994). The MMIHS was designed as a longitudinal population-based case-control study of all very low birth weight infants born to Missouri residents between 1989 and 1991. This project was coordinated by the State of Missouri Department of Health, with support

for data collection and analysis provided by faculty in the Department of Health Psychology, the Department of Child Health, and the Department of Communication Science and Disorders at the University of Missouri-Columbia. Data were made available for the current study by the MMIHS co-investigators.

Participants were first surveyed between 1989 and 1991 and again between 1999 and 2001, approximately 10 years later. Case and control participants were identified through two sources: 1) the labor and delivery logs of five major urban hospitals that provide health care to low-income individuals and 2) birth records provided by the Missouri Department of Health. Each very low birth weight (VLBW) case identified through hospital delivery logs was matched with both a normal birth weight (NBW; born weighing 2,500 grams or more) and low birth weight (LBW; born weighing between 1,500-2,500 grams) control on race (black, white) and maternal age (10-19, 20-24, 25 or more). Specifically, controls were the next women in the same strata (i.e., race and maternal age) who delivered LBW or NBW infants at the same hospital. Similar to the process for matching participants from the hospital labor and delivery logs, each VLBW case identified through infant birth records was matched with a LBW and NBW control using stratified random sampling. In addition to matching on race and maternal age, these controls were also matched on urban versus rural residency (St. Louis City, St. Louis County, and Kansas City and Jackson County combined, versus the rest of Missouri). Controls were selected monthly, and distributions were evaluated every three months and adjusted when necessary to maintain the appropriate distribution among the strata. Although participants were grouped by birth weight category for sampling purposes, the current study used birth weight as a continuous measure.

At baseline, the target sample (including both cases and controls) consisted of 4,104 mother-infant dyads. Questionnaires were completed by 3,102 of these mothers for a 76 percent overall participation rate. Response rates were slightly higher for participants identified through hospital delivery logs compared with mothers identified through birth and death certificate records (84 versus 70 percent, respectively). Efforts to match cases and controls resulted in participation that was similar across demographic groupings, although slightly higher response rates were found for white mothers, young mothers, and mothers residing in rural areas.

For the 10 year follow-up, efforts were made to contact as many of the original MMIHS participants as possible. Ultimately, 1548 families were located, and parents/guardians of 876 children agreed to complete the follow-up questionnaire. Families who provided complete data on both the birth (T1) and 10 year follow-up (T2) questionnaires were included in the analytic sample for the current study. Additionally, to maintain the independence of the data, we randomly selected one child from each twin (n = 31) and triplet (n = 3) birth in cases where data were available for all of the children. Demographic characteristics for the final sample of 771 mother-child dyads are presented in Table 4.

Attrition analyses revealed that our follow-up sample differed from the original MMIHS sample on several demographic variables. Specifically, this sample included significantly fewer children of a racial or ethnic minority background (χ^2 (1, N = 2421) = 77.80, $p < .001$) and fewer children whose mothers reported smoking cigarettes during pregnancy (χ^2 (1, N = 2410) = 6.21, $p < .05$). Group differences were also found in maternal educational attainment and marital status, with participants in the follow-up

sample being more educated (χ^2 (3, N = 2425) = 77.50, p < .0001) and more likely to be married (χ^2 (1, N = 2425) = 69.88, p < .0001) than those who provided data only at baseline. Children who were and were not followed up did not differ with respect to biological sex, birth weight, or gestational age.

Procedure

Primary sources of data for the MMIHS included a) birth certificates that provide information on demographic characteristics and pregnancy outcomes, and b) a comprehensive questionnaire designed to elicit pregnancy and health-related information from new mothers (e.g., pregnancy determination and prenatal care, general health and use of medications/drugs during pregnancy, birth control and reproductive history, information on substance use, social support, employment and other daily activities, personal and household characteristics, postpartum health care, and their infants' health and special care needs).

At baseline, questionnaire data were gathered from participants in several ways. The majority of survey responses were obtained through questionnaires mailed to mothers at three months postpartum (66%), with the remainder obtained through face-to-face interviews in the five hospitals (20%), questionnaires completed by respondents while in the hospital (12%), and telephone interviews (2%). For the participants selected through hospital delivery logs, hospital personnel were responsible for interviewing mothers either before discharge or by mail, or by inviting them back to the hospital to be interviewed in person. Attempts to solicit participants identified through birth certificates followed a three mailing plus telephone follow-up procedure. In cases where these efforts were unsuccessful, community health workers or social workers attempted to conduct in-

person or telephone interviews. Mothers were compensated $15.00 for completing the survey.

For the 10-year follow-up, data were collected from parents and/or guardians as well as child participants. Caregivers completed a questionnaire asking them to report on aspects of their child's health and emotional/behavioral well-being, and were also asked to come to the university laboratory for children's cognitive and language testing. All procedures were approved by the Campus Institutional Review Board at the University of Missouri and conducted following their policies. Caregiver consent was obtained for those children who participated in the laboratory testing. For the current study, only data obtained through the child health questionnaires were used.

Measures

Demographics. Four demographic characteristics (i.e., child sex, race/ethnicity, maternal marital status, and maternal education level) and one prenatal factor (i.e., maternal smoking during pregnancy) were included as control variables. Child sex and child race/ethnicity were ascertained from children's birth certificates. Because other minority representation (e.g., Asian, Hispanic) was not significantly present, race/ethnicity was dichotomized, with 1 = Caucasian, non-Hispanic and 2 = racial or ethnic minority. Information on smoking during pregnancy was derived from the birth certificate data. For the present study, prenatal cigarette exposure was a two level variable, with 1 = exposed and 2 = not exposed.

Birth weight. Birth certificate records provided information regarding infants' birth weight. Birth weight (in grams) was measured as a continuous variable.

Maternal psychological functioning. A composite measure representing maternal

psychological distress was created based on mothers' responses to a multi-part question in the baseline maternal questionnaire asking them to indicate the extent they agreed or disagreed with each of 18 statements relating to aspects of their current psychological functioning. These 18 statements were adapted from three existing measures. Seven statements were drawn from the Mastery Scale, a 7-item measure assessing the extent to which an individual views him or herself as being in control of the forces that importantly affect his or her life (Pearlin, Menaghan, Lieberman, & Mullan, 1981). Six statements were drawn from the 10-item Rosenberg Self-Esteem Scale, a widely used measure of an individual's overall evaluation of his/her worth or value (Rosenberg, 1989). The final five statements indexed common symptoms of depression (i.e., lacked enthusiasm for doing anything, difficulty sleeping, feeling downhearted or blue, feeling bored and having little interest in doing things, feeling low in energy), and were adapted from the Symptom Checklist 90 – Revised, a well-validated questionnaire assessing psychological symptomatology (SCL-90-R; Derogatis, 1994).

Agreement or disagreement with each of the 18 statements was measured using a 5-point Likert scale (1 = strongly agree to 5 = strongly disagree). Items were reverse scored as necessary prior to computing a sum of all items, so that a higher total score indicated poorer psychological functioning (i.e., low sense of mastery/control, low self-esteem, and more severe depressive symptomology). This composite measure of maternal psychological functioning demonstrated good internal reliability ($\alpha = .86$).

Neonatal medical complications. A composite measure reflecting the extent of infant medical complications at birth was created using information from the infants' birth certificates and mother-report questionnaires. The neonatal medical complications

index included the following indicators: a) 5-minute APGAR score (ranges from 0 to 10, reverse scored so that higher scores indicated greater need for resuscitative measures following delivery), b) length of stay in the hospital following birth (1 = 1 day or less, 2 = 2-3 days, 3 = 4-7 days, 4 = 8 to 13 days, 5 = 2 to 4 weeks, 6 = more than 4 weeks), c) need for ventilator support (0 = no, 1 = yes), d) need for supplemental oxygen (independent of ventilator support) (0 = no, 1 = yes), e) need for intravenous feedings (0 = no, 1 = yes), f) required surgery prior to release from hospital (0 = no, 1 = yes), g) IVH determined by ultrasound (0 = no, 1 = yes), and h) hydrocephalus, enlarged chambers, or enlarged ventricles determined by ultrasound (0 = no, 1 = yes). To create the composite measure, participant responses for the six dichotomous constituent variables were summed to create a new variable ranging from 0 to 6. Bivariate correlations between this variable and the two remaining indictors of neonatal medical complications (i.e., 5-minute APGAR score, length of time spent in the hospital following birth) were significant ($r = .58$, $p < .0001$ and $r = .78$, $p < .0001$, respectively). Infants' 5-minute APGAR scores (reverse-scored) and length of time spent in the hospital following birth were also significantly associated ($r = .51$, $p < .0001$). Thus, the composite measure indexing the extent of neonatal medical complications at birth was computed as the mean of the standardized (0, 1) three constituent scores. This measure demonstrated good internal reliability ($\alpha = .83$).

Emotional and behavioral adjustment. Children's emotional and behavioral adjustment at age 10 years was assessed using the long form of the Conners' Parent Rating Scale - Revised (CPRS-R; Conners, Sitarenios, Parker, & Epstein, 1998). The CPRS-R is widely used in both research and clinical settings to obtain parent reports of

children's behavior problems. Although the short version of this tool is designed specifically to assess children's ADHD symptoms, the long form was normed using a large, representative sample of children and contains scales that measure childhood behavior problems more broadly. The 80-item CPRS-R asks parents to describe aspects of their children's behavior (e.g., mood changes quickly and drastically, touchy or easily annoyed by others) using a 4-point scale with answers ranging from 'not true at all' to 'very much true.'

Seven subscale scores are computed from parents' responses, including cognitive problems/inattention, oppositional, hyperactivity-impulsivity, anxious-shy, perfectionism, psychosomatic, and social problems. Although the CPRS-R does not allow for the computation of a depression subscale, some symptoms of depression are measured within the available subscales. Specifically, items on the CPRS-R ask parents to report on children's mood (e.g., irritability, cries often and easily) as well as their psychosomatic symptoms (e.g., reports frequent stomach aches, complains of being sick when nothing is wrong). Psychometric properties of the CPRS-R are well-established and have been determined to be acceptable, demonstrated by good internal reliability coefficients, high test-retest reliability, and good discriminatory power (see Conners, Sitarenios, Parker, & Epstein J., 1998). In addition, the CPRS has also shown good concurrent validity with other established parent rating scales assessing a range of childhood behavioral problems, including the Child Behavior Checklist (e.g., Achenbach & Edelbrock, 1983) and the Behavior Problem Checklist (Arnold, Barnebey, & Smeltzer, 1981; Campbell & Steinert, 1978).

Results

Descriptive Associations Among Study Variables

Table 5 summarizes the means, standard deviations, and bivariate associations among children's birth weight, neonatal medical complications, maternal psychological distress, and children's emotional and behavioral outcomes. Lower birth weight was associated with more severe neonatal medical complications at birth and greater maternal psychological distress. Lower birth weight was also related to increased emotional and behavioral difficulties at age 10, indicated by higher scores on all CPRS-R subscales (i.e., cognitive problems/inattention, oppositional, hyperactivity-impulsivity, anxious-shy, perfectionism, psychosomatic, and social problems; see Table 5). No association was found between neonatal medical complications and maternal psychological distress, however, both of these predictors were significantly related to all seven CPRS-R subscale scores. Specifically, more severe neonatal medical complications and greater maternal psychological distress at baseline were both related to poorer emotional and behavioral outcomes at T2.

Mediating Effects of Neonatal Medical Complications

Procedures for testing mediation as outlined by Baron and Kenny (1986) were followed to test our hypotheses relating to the mediating role of neonatal medical complications (*for a description, see Study 1)*. First, we predicted children's psychosocial adjustment outcomes at age 10 from birth weight. Results of these analyses are summarized in Table 6. After statistically controlling for the five covariates, birth weight significantly predicted children's scores on all CPRS-R subscales. Specifically, children born with lower birth weights demonstrated poorer adjustment with respect to both

externalizing and internalizing outcomes. These findings satisfy the first condition necessary to establish mediation (i.e., the predictor must be significantly related to the criterion).

The association between neonatal medical complications and birth weight was then considered in a second regression analysis. Key findings showing that neonatal medical complications continued to be significantly related to birth weight after the effects of the covariates were taken into account are presented in Table 6. In addition, results of this regression analysis suggested that male infants and Caucasian infants experienced more severe medical complications at birth, while maternal smoking during pregnancy was associated with less severe infant medical complications. Maternal educational attainment was marginally related to neonatal medical complications such that children of mothers who were more educated had more severe medical complications at birth. Mothers' marital status was unrelated to infant neonatal medical complications.

Birth weight and neonatal medical complications were included as predictors of child adjustment in a final series of regression models to test whether the third condition required to establish mediation was met (i.e., the mediator must significantly affect the dependent variable). In the current study, no association was found between neonatal medical complications and children's scores on the CPRS-R hyperactivity, oppositional, and psychosomatic subscales. Thus, the third condition was not met for these outcomes and they were not examined in subsequent models testing for mediation. However, significant positive associations were observed between neonatal medical complications and children's scores on the CPRS-R anxious/shy, cognitive problems/inattention, perfectionism, and social problems subscales (Table 6).

Because (a) birth weight predicted neonatal medical complications, (b) birth weight predicted children's CPRS-R scores, and (c) neonatal medical complications predicted CPRS-R anxious/shy, cognitive problems/inattention, perfectionism, and social problem subscale scores, the initial conditions for a mediator model were met for these outcomes. Thus, we tested the fourth condition necessary to establish mediation. In separate regressions, we examined whether after controlling for the effect of neonatal medical complications, the significant effect of birth weight on children's adjustment was eliminated or significantly reduced. Our regression models using CPRS-R anxious/shy, cognitive problems/inattention, perfectionism, and social problems subscales as the criterion variables met this condition. First, the effect of birth weight on children's anxious/shy behavior (β = -.16, $p < .0001$) became non-significant with the inclusion of neonatal medical complications in the model (β = -.06, *ns*). Significance testing of this difference using a Sobel test showed that the decrement in prediction was statistically significant (Sobel test = -2.42, $p < .05$). Second, the effect of birth weight on children's cognitive problems/inattention (β = -.18, $p < .0001$) became non-significant with the inclusion of neonatal medical complications in the model (β = -.08, *ns*). Significance testing of this difference using a Sobel test showed that the decrement in prediction was statistically significant (Sobel test = -2.51, $p < .05$). Third, the effect of birth weight on children's perfectionism (β = -.09, $p < .05$) became non-significant with the inclusion of neonatal medical complications in the model ((β = -.01, *ns*). Significance testing of this difference using a Sobel test showed that the decrement in prediction was statistically significant (Sobel test = -1.96, $p < .05$). Finally, the effect of birth weight on children's social problems (β = -.12, $p < .01$) became non-significant with the inclusion of neonatal

medical complications in the model ($\beta = .02$, *ns*). Significance testing of this difference using a Sobel test showed that the decrement in prediction was statistically significant (Sobel test = -3.44, $p < .001$). Thus, the severity of medical complications at birth mediated the relation between birth weight and children's anxious/shy behavior, cognitive problems/inattention, perfectionism, and social problems.

Maternal Psychological Functioning as a Moderator

The secondary objective of the current study was to examine whether the mediating effect of neonatal medical complications on the relation of birth weight to child outcomes depended on maternal psychological distress. Because evidence for a mediating effect of neonatal medical complications was found for CPRS-R anxious/shy, cognitive problems/inattention, perfectionism, and social problems subscales, moderated mediation analyses were conducted for these outcomes only. For each adjustment outcome, the final regression model establishing mediation was used as the foundation for testing moderated mediation. Specifically, birth weight and neonatal medical complications were included as predictors of each child adjustment variable, along with the same covariates used previously (i.e., child sex, race/ethnicity, maternal marital status and educational attainment, and prenatal cigarette exposure). Maternal psychological functioning and the interaction between maternal psychological functioning and neonatal medical complications were added to the mediation regression model to test moderated mediation as hypothesized in Figure 2. Although maternal psychological functioning was associated with children's CPRS-R cognitive problems/inattention subscale scores ($\beta = .09$, $p < .05$) and social problems ($\beta = .13$, $p < .001$), the interaction between maternal psychological functioning and neonatal medical complications was not a significant

predictor of these adjustment indices or children's anxious-shy and perfectionism scores. Thus, the moderated mediation hypothesis illustrated in Figure 2 was not supported.

Testing Alternative Moderated Mediation Models

As noted in Study 1, alternative moderated mediation models have been developed. In an attempt to better understand the complex relations among primary study variables in the MMIHS, a series of exploratory analyses designed to investigate the other possible moderated mediation frameworks were conducted. First, we tested an alternative model in which maternal psychological functioning moderates the relation between birth weight and neonatal medical complications (Figure 3; bold paths represent the model under consideration). This model was examined statistically by testing a regression equation predicting neonatal medical complications from the five covariates, birth weight, maternal psychological distress, and the interaction between birth weight and maternal psychological distress. Findings from this analysis did not provide support for moderated mediation as depicted in Figure 3, as the magnitude of the indirect effect of birth weight on neonatal medical complications did not vary as a function of maternal psychological distress (β = -.04, *ns*).

Next, we tested a model in which maternal depression moderates the relation of birth weight to child adjustment outcomes, independent of the effect of neonatal medical complications (Figure 5). We conducted a series of regression analyses predicting CPRS-R anxious/shy, cognitive problems/inattention, perfectionism, and social problem scores from the five control variables, birth weight, maternal psychological distress, and the interaction between birth weight and psychological functioning. Results of these analyses showed that although maternal psychological functioning predicted CPRS-R cognitive

problems/inattention ($\beta = .09$, $p < .05$) and social problem ($\beta = .13$, $p < .001$) subscales scores, the relation of birth weight to children's emotional and behavioral adjustment outcomes was not moderated by maternal psychological functioning for children's anxious-shy, perfectionism, and social problem scores. Additionally, the interaction between birth weight and maternal psychological functioning was not significant ($\beta = .06$, $p > .05$).

Finally, it is possible that maternal psychological functioning moderates both the indirect effect of neonatal medical complications on child adjustment, and the residual effect of birth weight on children's adjustment outcomes (after controlling for neonatal medical complications) (Figure 6). To explore this possibility, we tested four separate regression models predicting each of the child adjustment outcomes from the control variables, birth weight, maternal psychological functioning, the interaction between birth weight and psychological functioning, neonatal medical complications, and the interaction between neonatal medical complications and maternal psychological functioning. Results of these analyses did not provide support for the model of moderated mediation depicted in Figure 6 for any of the child adjustment outcomes examined (i.e., anxious/shy, cognitive problems/inattention, perfectionism, and social problems).

Discussion

The overarching goal of the present studies was to better understand how low birth weight affects children's emotional and behavioral development. An important contribution of the current investigation was that we examined the association of birth weight to children's psychosocial functioning using a longitudinal design as well as at two distinct developmental periods. Our findings replicated and build on previous work

showing that low birth weight exerts small adverse effects on children's temperament characteristics during toddlerhood, but demonstrated a stronger negative influence on psychosocial functioning in late childhood. We further extended previous research by examining medical complications as one possible mechanism through which birth weight might affect adjustment outcomes. The most consistent findings in this regard suggested that a history of neonatal medical complications, rather than birth weight, played a critical role in determining certain types of adjustment outcomes in late childhood. From a methodological perspective, it is noteworthy that the current studies improved upon the methods of earlier work by including large numbers of the most high-risk infants (i.e., those born with very low birth weights), and by statistically controlling for variables that might obscure the nature of the relation between birth weight and outcomes (e.g., prenatal cigarette exposure, maternal educational attainment). Findings concerning the aforementioned contributions are now discussed in greater detail.

The strongest associations of low birth weight to poorer emotional and behavioral outcomes were observed in late childhood. As expected, smaller infants demonstrated increased difficulties related to cognitive functioning/attention and hyperactivity. These child problems are among the most replicated outcomes of low birth weight in both cross-sectional and prospective, population-based studies (e.g., Anderson & Doyle, 2003; Bhutta, et al., 2002; Lehn, Derks, Hudziak, Heutink, van Beijsterveldt, & Boomsma, 2007; Mick et al., 2002; Nigg & Breslau, 2007; Saigal et al., 2003). Low birth weight was associated with internalizing problems, especially anxious-shy behavior but also perfectionism and psychosomatic symptoms. The adverse effect of low birth weight on risk for later internalizing problems is less well-established, however, our findings are

consistent with several recent studies reporting higher rates of depression and anxiety in low birth weight samples (Costello et al., 2007; Gardner et al., 2004; Indredavik et al., 2004). Children with lower birth weights also exhibited more social problems at age 10 than children with higher birth weights. Prior investigation of the social functioning and adaptive behavior of children born with low birth weights has been relatively limited (notable exceptions include Elgen, Sommerfelt, & Markestad, 2002; Gardner et al., 2004; Hoy et al., 1992; Schothorst, & van Engeland, 1996; Sommerfelt, et al., 1996; Weindrich et al., 2003), thus, this finding represents an important contribution to the literature. Finally, low birth weight had a small association with children's oppositional scores. This finding is consistent with previous research suggesting that social risk factors (e.g., family adversity) are more influential than birth weight in determining conduct and antisocial behavior disorders (Nadeau et al., 2003; Weindrich et al., 2003).

Predictive Value of Neonatal Health Status

Importantly, our results showed that the adverse effect of low birth weight on several of these psychosocial outcomes is indirect through children's health status at birth. Specifically, the associations between birth weight and school-aged adjustment difficulties related to anxious/shy behavior, cognitive functioning/inattention, perfectionism, and social problems were mediated by neonatal medical complications. Previous studies have documented an incremental predictive value for perinatal health problems beyond birth weight in regression models (Girouard et al., 1998; Taylor, Klein, Drotar, Schluchter, & Hack, 2006; Whitaker et al., 1997). However, only a few studies have investigated how these factors might jointly affect children's later psychosocial outcomes (e.g., Miceli et al., 2000). Although the size of the mediation effects found in

the current study were modest, they are of considerable theoretical interest because they provide direct evidence supporting the widely held assumption that neonatal health status rather than birth weight per se leads to poorer outcomes in preterm/low birth weight samples.

In the current studies, neonatal medical complications was operationalized as a constellation of health-related factors. These health-related factors included aspects of the early life experience that indicate the presence of medical problems at birth (e.g., lower APGAR scores), as well as more direct measures of specific infant health conditions (e.g., hydrocephalus). Our mediation results suggest that children who demonstrated certain types of adjustment difficulties in late childhood (i.e., cognitive problems/inattention, social problems, anxious-shy behavior, and psychosomatic symptoms) required greater resuscitation efforts immediately following their births and were hospitalized for longer periods as neonates. Moreover, our findings suggest that these children experienced specific medical problems, such as seizures, respiratory distress syndrome, or brain hemorrhages, at higher rates than children who did not have problems with attention, social functioning or anxiety/shyness at age 10.

Neural mechanisms. How might these effects work? One possibility is that early medical complications result in permanent changes in brain structure or neurochemistry that have detrimental effects on children's adjustment outcomes (Carmody et al., 2006; Pennington, 2001; Plomin, 1994). Neuropsychological effects appear to be particularly influential in determining outcomes related to cognitive functioning and attention in low birth weight samples (Aylward, 2002; Caldu, Narberhaus, Junque, Gimenez, Vendrell, Bargallo, et al., 2006; Carmody, Bendersky, Dunn, DeMarco, Hegyi, Hiatt, et al., 2006;

Cooke & Abernethy, 1999; Nadeau, Tessier, Boivin, Lefebvre, & Robaey, 2003; Vollmer, Roth, Riley, O'Brian, Baudin, De Haan, et al., 2006). Illustratively, results from one recent study found that ADHD symptoms but not other psychiatric symptoms in adolescence survivors of very low birth weight were associated with white matter reduction and thinning in the corpus callosum (Indredavik, Skranes, Vik, Heyerdahl, Romundstad, Myhr et al., 2005).

A similar mechanism in terms of neurological functioning might explain the associations between early medical complications and later social problems, anxious-shy behavior, and psychosomatic scores (De Bellis et al., 2000; Kruesi, Casanova, Mannheim, & Johnson-Bilder, 2004; Rosso et al., 2005). Illustratively, compromised newborn health may lead to structural changes in brain regions that are associated with the regulation of emotionality and mood (e.g., the limbic system) which in turn influence children's behavior and psychosocial functioning. Although this explanation makes sense from a theoretical standpoint, empirical investigation of the relations among early medical complications, brain morphology, and children's psychosocial outcomes is currently lacking. However, a large body of research has documented associations between social/environmental factors and children's emotional and behavioral functioning (Cummings, Davies, & Campbell, 2000; Deater-Deckard, Dodge, Bates, & Pettit, 1998; Dodge & Pettit, 2003). Briefly, social/environmental risk factors for poorer adjustment include family environment factors (e.g., parental psychopathology, parenting), aspects of peer relationships (e.g., peer rejection/isolation, associations with deviant peers), and the broader contextual context (e.g., neighborhood crime, poverty). These findings suggest that an alternative explanation for the observed mediating effects

is that social or environmental factors associated with the experience of neonatal medical complications negatively influence children's later adjustment outcomes.

Environmental mechanisms. Previous research suggests several potentially important social/environmental consequences of neonatal medical complications. Early medical complications are associated with lengthy infant hospitalizations and extensive medical interventions following birth (Allen, Lewinsohn & Steeley, 1998; Browne & Talmi, 2005). After discharge from the hospital, infants who had early medical complications frequently require continued medical services to treat ongoing problems (e.g., physical disabilities). Health care utilization remains substantially higher in this population throughout childhood and adolescence, due to the increased risk for various chronic health conditions (e.g., asthma, obesity, diabetes) associated with early medical complications (Costello et al., 2007; Gray, Woodward, Spencer, Inder, & Austin, 2006; Sweet et al., 2003). Compromised infant health status has also been found to negatively impact the family. Illustratively, medical problems and their sequalae are associated with increased emotional distress in parents, disrupted social and family relationships, and considerable financial burden (Moore, Taylor, Klein, Minich, & Hack, 2005; Singer et al., 2003; Petrou, Henderson, Bracewell, Hockley, Wolke, & Marolow, 2006; Swaminathan, Alexander, & Boulet, 2006; Tommiska, Ostberg, & Fellman, 2005).

These social and environmental aspects of early medical complications might set off a cascade of other risk factors that have been shown to exert adverse effects on children's psychosocial adjustment during childhood and adolescence (e.g., increased family adversity) (Cicchetti & Toth, 1997; Repetti, Taylor, & Seeman, 2002). Illustratively, the neonatal intensive care unit experience and/or children's subsequent

health care needs might lead mothers to perceive greater child vulnerability (e.g., Stern, Karraker, McIntosh, Moritzen, & Olexa, 2006) and cause them limit child activities that can provide important socialization experiences (e.g., contacts with peers). Lengthy hospitalizations and increased parental distress may also result in lower quality mother-infant interactions, which can in turn adversely affect children's achievement of important developmental tasks (e.g., formation of the attachment relationship, achievement of self-regulation). Problems in these domains may result in subsequent difficulties (e.g., poor school performance, compromised family relationships) that further exacerbate children's risk for adjustment problems. Closer examination of social/environmental risk factors in children with perinatal medical complications represents an important direction for future research.

Unexpected Findings

It is unclear why the associations between birth weight and children's oppositional behavior, hyperactivity, and perfectionism were not mediated by neonatal medical complications. One possible explanation is that these outcomes are influenced by a different set of risk factors than those affecting the adjustment of children born with perinatal health problems. Illustratively, poorer adjustment outcomes in relatively healthy low birth weight children may be related to other risk factors that are frequently associated with prematurity/low birth weight (e.g., poor maternal health or substance use, domestic violence) (Alexander & Slay, 2002; Kramer et al., 2001; National Center for Health Statistics, 2004; Paneth, 1995). Future studies replicating our findings of a differential mediating effect for neonatal medical complications are needed in order to

make a stronger statement regarding the specificity of this predictor in relation to children's psychosocial outcomes.

Given evidence for the detrimental effect of birth weight on psychosocial adjustment in late childhood, our finding that low birth weight demonstrated a small effect on children's emotional and behavioral characteristics in toddlerhood (i.e., child regulatory difficulties, less positive affect/sociability, and more negative affect/low engagement) was unexpected. Likewise, the lack of association between neonatal medical problems and indices of children's socioemotional adjustment in toddlerhood was unanticipated and contrasts with previous work suggesting that biological factors (e.g., health status) are a more dominant influence on the early behavioral outcomes of low birth weight infants than social factors (Ross et al., 1990; Weislgas-Kuperus, et al 1993). A possible reason for these results is that our measure of medical complications in this sample did not adequately capture the extent of problems experienced by some of the low birth weight children. In Study 1, information related to specific newborn conditions (e.g., IVH) was ascertained from infants' birth certificates. Birth certificate data has been criticized on the grounds that information regarding birth complications and newborn conditions commonly underreported (Headley, Fulcomer, Bastardi, Im, Sass, & Chung, 2006). Thus, future studies investigating the links between neonatal medical complications and early socioemotional development might more accurately quantify early health problems by using detailed parent report measures or medical chart abstractions.

Temperament. The majority of previous work investigating temperament in preterm or low birth weight infants has found that low birth weight infants demonstrate

characteristics reflecting difficult temperament at higher rates than normal birth weight infants (e.g., Case-Smith, Butcher, & Reed, 1998; Garcia Coll, Halpern, Vohr, Seifer, & Oh, 1992; Hughes, Shultz, McGrath, & Medoff-Cooper, 2002; Langkamp, Kim, & Pascoe, 1998; Singer et al., 2003; Stiefel, Plunkett, & Meisels, 1987). However, these studies have primarily examined temperament characteristics during the first few months of life and have relied on parents for information about children's behavioral characteristics. It is noteworthy that studies using observational measures of temperament later in infancy or during toddlerhood report findings more consistent with our results, specifically, that the adverse effect of low birth weight on temperament is relatively minimal (Goldstein & Bracey, 1988; Gorman, Lourie, & Choudhury, 2001; Halpern et al., 2001; Newman et al, 1997; Oberklaid et al., 1991; Riese, 1994; Sajaniemi, Salokorpi, & von Wendt, 1998; Scher, Steppe & Banks, 1996; Robson & Cline, 1998; Watt, 1987).

Two theories have been offered in the literature to explain the apparent diminishing influence of low birth weight on children's temperament characteristics. One explanation is that that the adverse effect of low birth weight on temperament represents a short-lived difficult developmental stage that moderates with increasing physical development. Evidence from several other lines of research supports this idea. Studies examining patterns of fetal and infant development have shown a high growth velocity in the brain during the late intrauterine and early postnatal periods (Cooke, 2006). Given that a majority of low birth weight infants are preterm and thus have shortened gestation, they are typically less physically mature at birth than their normal weight counterparts. This biological immaturity may have important implications for temperament characteristics, as some brain systems linked with early behavioral responding are among

those that develop during the third trimester and early postnatal period (Fox, Henderson, & Marshall, 2001; Calkins & Fox, 1994; Halpern & Garcia Coll, 2000; Nelson, 1994; Rothbart, Derryberry, & Posner, 1994). However, barring any antenatal influences that further compromise growth in the postnatal period (e.g., inadequate nutrition; Gordon, 1997), with increasing brain development low birth weight infants are able to attain sufficient maturity to reduce or eliminate group differences in temperament by the end of the first year of life. Thus, in this framework, low birth weight infants are in reality more temperamentally difficult than their normal birth weight counterparts, however, this early difficultness is a time-limited phenomenon that dissipates with advancing neurological development.

Alternatively, it is possible that the early differences in temperament between low and normal birth weight infants are an artifact of factors such as maternal reporting bias or parenting efficacy. Consistent with this perspective, there may be a tendency for mothers of low birth weight infants to perceive their babies as more difficult or challenging initially because they feel overwhelmed or are stressed by the challenges of caring for their infants. Increasing time spent with their infants, however, provides mothers with more frequent opportunities to become familiar with their children's cues and more effective at responding. Consequently, group differences in temperament characteristics between low and normal birth weight infants may appear to diminish over time as mothers of low birth weight infants adapt to their babies and feel more efficacious with respect to their parenting skills. Future studies that use both parent-report and observational measures of temperament and collect information at several time points across infancy and toddlerhood are needed to help clarify the effect of low birth weight

on children's early behavioral characteristics. Indeed, this is an attribute of the current study, as we examined both parent-reported (i.e., regulatory difficulties) and interviewer-observed (i.e., positive affect/sociable and negative affect/low engagement) temperament outcomes.

Role of maternal psychological functioning. Finally, results of our exploratory moderated mediation analyses did not provide convincing evidence that maternal psychological functioning interacts with medical complications to produce outcomes in late childhood.[4] A possible reason for this is that our composite measure of maternal psychological functioning was too general and thus did not adequately capture the extent of mothers' distress. Examination of this hypothesis using a more specific assessment of maternal depression may result in different findings. Additionally, other social/environmental risk factors may be important to consider as moderators. For example, a large literature now documents the adverse effects of parenting stress on children's developmental outcomes (Crnic, Gaze, & Hoffman, 2005; Deater-Deckard, 2004; Haskett, Ahern, Ward, & Allaire, 2006). Given that increased parenting stress in mothers of infants born preterm or low birth weight is common, it is possible that the mediating effects of medical complications on child outcomes are stronger in the context of greater parenting stress. In other words, early medical problems (or associated factors, such as increased child difficulty) may lead to adverse outcomes only when mothers experience high levels of parenting stress. Another possibility is that aspects of parenting behavior may affect outcomes in children who experience significant medical complications at birth. Illustratively, medical complications may have neurological effects (e.g., increased behavioral inhibition or fearful temperament). This may in turn

affect aspects of parenting (e.g., intrusiveness, protectiveness), which interact with children's behavioral styles to produce adverse outcomes (e.g., social anxiety, shyness) (Rapee, 2001; Rubin, Burgess, & Hastings, 2002; Rubin, Nelson, Hastings, & Asendorpf, 1999).

Thus, although we did not find strong evidence for moderated mediation in the current study, these exploratory analyses represent an important methodological contribution to the existing literature by highlighting the importance of considering the possible joint impact of biological and social factors on children's outcomes. In addition, we described a method that can be useful for testing these types of research questions in future studies. Tests of alternative moderated mediation models using some of the aforementioned influences (e.g., parenting stress, parenting behavior) could further our understanding of the relations among birth weight, medical complications, social/contextual influences, and child psychosocial outcomes.

Limitations and Future Directions

Several limitations of the present studies and directions for future research should be noted. We explored our hypotheses regarding the relations among birth weight, neonatal medical complications, and children's later adjustment outcomes using two independent samples. Although we attempted to operationalize key constructs similarly across both studies, there were small differences in our measures that may limit the generalizability of our findings. Testing the relations among these variables in a single sample using a prospective longitudinal design would allow for more accurate conceptualization of how children's developmental trajectories may be influenced by birth weight. Moreover, although there were significant advantages of using the ECLS-B

(Study 1) and MMIHS (Study 2) datasets (e.g., large samples, information from numerous domains of functioning), neither dataset was specifically designed to address the research questions posed in the current investigation. One consequence of this is that some outcomes relevant to the current study were not assessed (e.g., depressive symptoms). Another consequence is that our measures may not have adequately captured the constructs intended. Illustratively, the null findings related to the hypothesized mediating effect of neonatal medical complications on children's temperament may reflect a problem with construct validity rather than a true lack of association between the study variables. Future studies using the most valid and reliable measures available (e.g., laboratory-based measures of child temperament, detailed medical chart abstraction) are needed to address this issue. Findings from the current investigation highlight some additional directions for future research. Specifically, studies identifying both the biological and social/environmental risk factors associated with children's early medical complications would help to clarify the associations between early infant health problems and later adjustment difficulties. Identification of these risk factors would allow researchers to test the hypothesis that certain adjustment problems associated with low birth weight reflect the combined influence of the neurological consequences of perinatal medical complications and the social/environmental aspects of poorer infant health status.

Conclusions

Children born with low birth weights are at increased risk for adjustment problems in late childhood, especially hyperactivity and oppositional behavior. Those who also experienced medical complications in early infancy are also at greater risk for later cognitive and attention problems, as well as difficulties that have more of an

interpersonal context (e.g., anxiety or shyness, psychosomatic symptoms, social problems). The mechanisms underlying these associations are not well understood. Early medical complications might affect these outcomes via neurological consequences, through social factors related to compromised infant health, or both. A better understanding of the risk factors associated with early medical complications would be useful in guiding early identification and intervention for low birth weight children who are at greatest risk of developing psychological problems.

References

Achenbach, T. M., & Edelbrock, C. (1983). *Manual for the Child Behavior Checklist and Revised Child Behavior Profile.* Burlington, VT: University of Vermont, Department of Psychiatry.

Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions.* Thousand Oaks, CA: Sage Publications.

Alexander, G. R., & Slay, M. (2002). Prematurity at birth: Trends, racial disparities, and epidemiology. *Mental Retardation and Developmental Disabilities Research Reviews, 8,* 215-220.

Allen, N. B., Lewinsohn, P. M., & Seeley, J. R. (1998). Prenatal and perinatal influences on risk for psychopathology in childhood and adolescence. *Development and Psychopathology, 10,* 513-529.

Anand, K. J. (2000). Effects of perinatal pain and stress. *Progress in Brain Research, 122,* 117-129.

Anderson, P., & Doyle, L. W. (2003). Neurobehavioral outcomes of school-age children born extremely low birth weight or very preterm in the 1990s. *Journal of the American Medical Association, 289,* 3264-3272.

Arcus, D. (2001) Inhibited and uninhibited children: Biology in the social context. In T. D. Wachs and G. A. Kohnstamm (Eds.), *Temperament in context* (pp. 43-60). Mahwah, NJ: Lawrence Erlbaum Associates.

Arnold, L. E., Barnebey, N. S., & Smeltzer, D. J. (1981). First grade norms, factor analysis, and cross correlation for Conners, Davids, and Quay-Peterson behavior rating scales. *Journal of Learning Disabilities, 14,* 269-275.

Aylward, G. P. (2002). Methodological issues in outcome studies of at-risk infants. *Journal of Pediatric Psychology, 27,* 37-45.

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality & Social Psychology, 51,* 1173-82.

Barrera, M. E., Rosenbaum, P. L., & Cunningham, C. E. (1987). Corrected and uncorrected Bayley scores: Longitudinal developmental patterns in low and high birth weight preterm infants. *Infant Behavior and Development, 10,* 337-346.

Bates, J. E. (1980). The concept of difficult temperament. *Merrill-Palmer Quarterly, 26,* 299-319.

Bates, J. E., Wachs, T. D., & Emde, R. N. (1994). Toward practical uses for biological concepts of temperament. In J. E. Bates and T. D. Wachs, Theodore (Eds.), *Temperament: Individual differences at the interface of biology and behavior* (pp. 275-306). Washington, DC: American Psychological Association.

Bates, J., Bayles, K., Bennett, D. S., Ridge, B., & Brown, M. M. (1991). Origins of externalizing behavior problems at eight years of age. In D. J. Pepler, and K. H. Rubin, (Eds.), *The development and treatment of childhood aggression* (pp. 93-120). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Bayley, N. (1993). *Bayley Scales of Infant Development: Second Edition.* San Antonio, TX: The Psychological Corporation.

Belsky, J., Friedman, S. L., & Hsieh, K. (2001). Testing a core emotion-regulation prediction: Does early attentional persistence moderate the effect of infant negative emotionality on later development? *Child Development, 72,* 123-133.

Belsky, J., Hsieh, K., & Crnic, K. (1998). Mothering, fathering, and infant negativity as antecedents of boys' externalizing problems and inhibition at age 3 years: Differential susceptibility to rearing experience? *Development and Psychopathology, 10,* 301-319.

Bendersky, M., & Lewis, M. (1994). Environmental risk, biological risk, and developmental outcome. *Journal of Developmental and Behavioral Pediatrics, 16,* 89-96.

Bennett, D. S., Bendersky, M., & Lewis, M. (2002). Children's intellectual and emotional-behavioral adjustment at 4 years as a function of cocaine exposure, maternal characteristics, and environmental risk. *Developmental Psychology, 38,* 648-658.

Bhutta, A. T., Cleves, M. A., Casey, P. H., Cradock, M. M., & Anand, K. (2002). Cognitive and behavioral outcomes of school-aged children who were born preterm: A meta-analysis. *Journal of the American Medical Association, 288,* 728-737.

Boehm, B., Katz-Salamon, M., Smedler, A., Langercrantz, H., & Forssberg, H. (2002). Developmental risks and protective factors for influencing cognitive outcomes at 5 ½ years of age in very-low-birth-weight children. *Developmental Medicine and Child Neurology, 44,* 508-516.

Botting, N., Powls, A., Cooke, R. W., & Marlow, N. (1997). Attention deficit hyperactivity disorders and other psychiatric outcomes in very low birthweight children at 12 years. *Journal of Psychology and Psychiatry, 38,* 931-941.

Boyce, G. C., Smith, T. B., & Casto, G. (1999). Health and educational outcomes of children who experienced severe neonatal medical complications. *Journal of Genetic Psychology. 160,* 261-270.

Breslau, N. (1995). Psychiatric sequelae of low birth weight. *Epidemiologic Reviews,17,* 96-106.

Breslau, N., & Chilcoat, H. D. (2000). Psychiatric sequelae of low birth weight at six years of age. *Biological Psychiatry, 47,* 1005-1011.

Briggs-Gowen, M. J., Carter, A. S., & Schwab-Stone, M. (1996). Discrepancies among mother, child, and teacher reports: Examining the contributions of maternal depression and anxiety. *Journal of Abnormal Child Psychology, 24,* 749-765.

Brooten, D., Gennaro, S., & Brown, L. P. (1988). Anxiety, depression, and hostility in mothers of preterm infants. *Nursing Research, 37,* 213-216.

Brown, K. J., Kilbride, H. W., Turnbull, W., & Lemanek, K. (2003). Functional outcome at adolescence for infants less than 801 g birth weight: Perceptions of children and parents. *Journal of Perinatology, 23,* 41-7.

Browne, J. V., & Talmi, A. (2005). Family-based intervention to enhance infant-parent relationships in the neonatal intensive care unit. *Journal of Pediatric Psychology, 30,* 667-677.

Caldu, X., Narberhaus, A., Junque, C., Gimenez, M., Vendrell, P., Nuria, S., et al. (2006). Corpus callosum size and neuropsychologic impairment in adolescents who were born preterm. *Journal of Child Neurology, 21,* 406-410.

Calkins, S. D., & Fox, N. A. (1994). Individual differences in the biological aspects of temperament. In J. E. Bates and T. D. Wachs, Theodore (Eds.), *Temperament:*

Individual differences at the interface of biology and behavior (pp. 199-217). Washington, DC: American Psychological Association.

Calkins, S. D., Gill, K. L., Johnson, M. C., & Smith, C. L. (1999). Emotional reactivity and emotional regulation strategies as predictors of social behavior with peers during toddlerhood. *Social Development, 8,* 310-334.

Campbell, S. B., & Steinert, Y. (1978). Comparison of rating scales of child psychopathology in clinic and nonclinic samples. *Journal of Consulting and Clinical Psychology, 46,*358-359.

Carey, W. B., & McDevitt, S. C. (1995). *Coping with children's temperament: A guide for professionals.* New York: Basic Books.

Carmody, D. P., Bendersky, M., Dunn, S. M., DeMarco, J. K., Hegyi, T., Hiatt, M., et al. (2006). Early risk, attention, and brain activation is adolescents born preterm. *Child Development, 77,* 384-394.

Case-Smith, J., Butcher, L., & Reed, D. (1998). Parents' report of sensory responsiveness and temperament in preterm infants. *American Journal of Occupational Therapy, 52,* 547-555.

Caspi, A., Henry, B., McGee, R. O., Moffitt, T. E., & Silva, P. A. (1995). Temperamental origins of child and adolescent behavior problems: From age three to age fifteen. *Child Development, 66,* 55-68.

Chapieski, M. L., & Evankovich, K. D. (1997). Behavioral effects of prematurity. *Seminars in Perinatology, 21,* 221-239.

Chi, T. C., & Hinshaw, S. P. (2002). Mother-child relationships of children with ADHD: The role of maternal depressive symptoms and depression-related distortions. *Journal of Abnormal Child Psychology, 30,* 387-400.

Cicchetti, D., & Toth, S. L. (1997). Transactional ecological systems in developmental psychopathology. In S. S. Luthar, J. A. Burack, D. Cicchetti, & J. Weisz (Eds). *Developmental psychopathology: Perspectives on adjustment, risk, and disorder* (pp. 317-349). New York: Cambridge University Press.

Cicchetti, D., Rogosch, F. A., & Toth, S. L. (1998). Maternal depressive disorder and contextual risk: contributions to the development of attachment insecurity and behavior problems in toddlerhood. *Development & Psychopathology, 10,* 283-300.

Conners, C. K., Sitarenios, G., Parker, J. D. A., & Epstein, J. N. (1998). The revised Conners' Parent Rating Scale (CPRS-R): Factor structure, reliability, and criterion validity. *Journal of Abnormal Child Psychology, 26,* 257-268.

Cooke, R. W. (2006). Are there critical periods for brain growth in children born preterm? *Archives of Disease in Childhood Fetal & Neonatal Edition, 91,* F17-20.

Cooke, R. W., & Abernethy, L. J. (1999). Cranial magnetic resonance imaging and school performance in very low birth weight infants in adolescence. *Archives of Diseases in Childhood: Fetal and Neonatal Edition, 81,* F116–21.

Costello, E. J., Worthman, C., Erkanli, A., & Angold, A. (2007). Prediction from low birth weight to female adolescent depression. *Archives of General Psychiatry, 64,* 338-344.

Creasey, G. L., Jarvis, P. A., Myers, B. J., Markowitz, P. I., & Kerkering, K. W. (1993). Mental and motor development for three groups of premature infants. *Infant Behavior and Development, 16,* 365-372.

Crnic, K. A., Gaze, C., & Hoffman, C. (2005). Cumulative parenting stress across the preschool period: Relations to maternal parenting and child behavior at age 5. *Infant and Child Development, 14,* 117-132.

Cronin, C. M., Shapiro, C. R., Casiro, O. G., & Cheang, M. S. (1995). The impact of very low-birth-weight infants on the family is long lasting: A matched control study. *Archives of Pediatrics & Adolescent Medicine, 149,* 151-8.

Cummings, E. M., Davies, P. T., & Campbell, S. B. (2000). *Developmental psychopathology and family process: Theory, research, and clinical implications.* New York: Guilford Press.

Curley, A. E., & Halliday, H. L. (2001). The present status of exogenous surfactant for the newborn. *Early Human Development, 61,* 67-83.

Dahl, L. B., Kaaresen, P. I., Tunby, J., Handegard, B. H., Kvernmo, S., & Rooning, J. A. (2006). Emotional, behavioral, social, and academic outcomes in adolescents born with very low birth weight. *Pediatrics, 118,* 449-459.

D'Angio, C. T., & Maniscalco, W. M. (2004). Bronchopulmonary dysplasia in preterm infants: pathophysiology and management Strategies. *Pediatric Drugs, 6,* 303-330.

Deater-Deckard, K. (2004). *Parenting Stress.* Yale University Press: New Haven, CT.

Deater-Deckard, K., Dodge, K. A., Bates, J. E., & Pettit, G. S. (1998). Multiple risk factors in the development of externalizing behavior problems: Group and individual differences. *Development & Psychopathology, 10,* 469-493.

De Bellis, M. D., Casey, B. J., Dahl, R. E., Birmaher, B., Williamson, D. E., Thomas, K. M., et al. (2000). A pilot study of amygdala volumes in pediatric generalized anxiety disorder. *Biological Psychiatry. 48,* 51-7.

Delobel-Ayoub, M., Kaminski, M., Marrett, S., Burguet, A., Marchand, L., N'Guyen, S. et al. (2006). Behavioral outcome at 3 years of age in very preterm infants: The EPIPAGE study. *Pediatrics, 117,* 1196-2005.

DeGangi, G. A., Poisson, S., Sickel, R. Z., & Weiner, A. S. (1995). *Infant/Toddler Symptom Checklist: A Screening Tool for Parents.* San Antonio, TX: The Psychological Corporation.

De Groote, I., Roeyers, H., Warreyn, P. (2006). Social-communicative abilities in young high-risk preterm children. *Journal of Developmental and Physical Disabilities, 18,* 183-200.

De Los Reyes, A., & Kazdin, A. E. (2005). Informant discrepancies in the assessment of childhood psychopathology: A critical review, theoretical framework, and recommendations for further study. *Psychological Bulletin, 131,* 483-509.

Derogatis, L. R. (1994). SCL-90-R: Administration, scoring, and procedures manual (3rd ed.). Minneapolis, MN: Derogatis.

Dodge, K. A., & Pettit, G. S. (2003). A biopsychosocial model of the development of chronic conduct problems in adolescence. *Developmental Psychology, 39,* 349-371.

Downey, G., & Coyne, J. C. (1990). Children of depressed parents: An integrative review. *Psychological Bulletin, 108,* 50-76.

Doyle, L. W. (2001). Outcome at 5 years of age of children 23 to 27 weeks' gestation: Refining the prognosis. *Pediatrics, 108,* 134-141.

Drewett, R., Blair, P., Emmett, P., & Emond, A. (2004). Failure to thrive in the term and preterm infants of mothers depressed in the postnatal period: A population-based birth cohort study. *Journal of Child Psychology & Psychiatry & Allied Disciplines, 45,* 359-366.

Duhig, A. M., Renk, K., Epstein, M. K., & Phares, V. (2000). Interparental agreement on internalizing, externalizing, and total behavior problems: A meta-analysis. *Clinical Psychology: Science and Practice, 7,* 435-453.

Eisenberg, N., Sadovsky, A., Spinrad, T., Fabes, R., Losoya, S. H., Valiente, C., et al. (2005). The relations of problem behavior status to children's negative emotionality, effortful control, and impulsivity: Concurrent relations and prediction of change. *Developmental Psychology, 41,* 193-211.

Elgar, F. J., Curtis, L. J., McGrath, P. J., Waschbusch, D. A., & Stewart, S. H. (2003). Antecedent-consequence conditions in maternal mood and child adjustment: A four-year cross-lagged study. *Journal of Clinical Child & Adolescent Psychology, 32,* 362-74.

Elgen, I., Sommerfelt, T., & Markestad, T. (2002). Population based, controlled study of behavioural problems and psychiatric disorders in low birthweight children at 11 years of age. *Archives of Disease in Childhood Fetal and Neonatal Edition, 87,* F128-F132.

Emgard, M., Paradisi, M., Pirondi, S., Fernandez, M., Giardino, L., & Calza, L. (2007). Prenatal glucocorticiod exposure affects learning and vulnerability of cholinergic neurons. *Neurobiology of Aging, 28,* 112-121.

Favaro, A., Tenconi, E., & Santonastaso, P. (2006). Perinatal factors and the risk of developing anorexia nervosa and bulimia nervosa. *Archives of General Psychiatry, 63,* 82-88.

Field, T. (1995). Infants of depressed mothers. *Infant Behavior & Development, 18,* 1-13.

Field, T. M., Hallock, N. F., Dempsey, J. R., & Shuman, H. H. (1978). Mothers' assessments of term and pre-term infants with respiratory distress syndrome: Reliability and predictive validity. *Child Psychiatry & Human Development, 9,* 75-85.

Fox, N. A., Henderson, H. A., & Marshall, P. J. (2001). The biology of temperament: An integrative approach. In C. A. Nelson, & M. Luciana (Eds.), *Handbook of Developmental Cognitive Neuroscience* (pp. 631-645). Cambridge, MA: MIT Press.

Fox, N. A., Henderson, H. A., Marshall, P. J., Nichols, K. E., & Ghera, M. M. (2005). Behavioral inhibition: Linking biology and behavior within a developmental framework. *Annual Review of Psychology, 56,* 235-262.

Frank, S. J., Van Egeren, L. A., Fortier, J. L., & Chase, P. (2000). Structural, relative, and absolute agreement between parents' and adolescent inpatients' reports of adolescent functional impairment. *Journal of Abnormal Child Psychology, 28,* 395-402.

Gale, C. R. & Martyn C. N. (2004) Birth weight and later risk of depression in a national birth cohort. *British Journal of Psychiatry*, 184, 28-33.

Garcia Coll, C. T., Halpern, L., Vohr, B. R., Seifer, R., & Oh, W. (1992). Stability and correlates of change of early temperament in preterm and full-term infants. *Infant Behavior and Development, 15,* 137-153.

Garcia Coll, C. T., Emmons, L., Vohr, B. R., Ward, M., Brann, B. S. Shaul, P. W., et al. (1988). Behavioral responsiveness in preterm infants with intraventricular hemorrhage. *Pediatrics, 81,* 412-418.

Gardner, F., Johnson, A., Yudkin, P., Bowler, U., Hockley, C., Mutch, L., et al. (2004). Behavioral and emotional adjustment of teenagers in mainstream school who were born before 29 weeks gestation. *Pediatrics, 114,* 676-682.

Gelfand, D. M., & Teti, D. M. (1990). The effects of maternal depression on children. *Clinical Psychology Review, 10,* 329-353.

Gennaro, S. (1988). Postpartal anxiety and depression in mothers of term and preterm infants. *Nursing Research, 37,* 82-85.

Gennaro, S., Tulman, L., & Fawcett, J. (1990). Temperament in preterm and full term infants at three and six months of age. *Merrill-Palmer Quarterly, 36,* 201-215.

Girouard, P. C., Baillargeon, R. H., Tremblay, R. E., Glorieux, J., Lefebvre, F., & Robaey, P. (1998). Developmental pathways leading to externalizing behavior in 5 year olds born before 29 weeks of gestation. *Journal of Developmental and Behavioral Pediatrics, 19,* 244-253.

Goldenberg, R. L., & Rouse, D. J. (1998). Medical progress: Prevention of premature birth. *The New England Journal of Medicine, 339,* 313-320.

Goldstein, D. J., & Bracey, R. J. (1988). Temperament characteristics of toddlers born prematurely. *Child: Care, Health and Development, 14,* 105-109.

Gordon. N. (1997). Nutrition and cognitive function. *Brain and Development, 19,* 165-170.

Gorman, K. S., Lourie, A. E., & Choudhury, N. (2001). Differential patterns of development: the interaction of birth weight, temperament, and maternal behavior. *Journal of Developmental and Behavioral Pediatrics, 22,* 366-375.

Gray, D., Woodward, L. J., Spencer, C., Inder, T. E., & Austin, N. C. (2006). Health service utilisation of a regional cohort of very preterm infants over the first 2 years of life. *Journal of Paediatrics and Child Health, 42,* 377-383.

Grills, A. E., & Ollendick, T. H. (2002). Issues in parent-child agreement: The case of structured diagnostic interviews. *Clinical Child & Family Psychology Review, 5,* 57-83.

Grunau, R. E., Holsti, L., Haley, D. W., Oberlander, T., Weinberg, J., Solimano, A., et al. (2005). Neonatal procedural pain exposure predicts lower cortisol and behavioral reactivity in preterm infants in the NICU. *Pain, 113,* 293-300.

Grunau, R. E. (2003). Self-regulation and behavior in preterm children: Effects of early pain. In P. J. McGrath and G. A. Finley (Eds.), *Pediatric pain: Biological and social context. Progress in Pain Research and Management* (23-55). Seattle, WA: IASP Press.

Grunau, R. E. (2002). Early pain in preterm infants: A model of long-term effects. *Clinical Perinatology, 29,* 373-94.

Guerin, D. W., Gottfried, A. W., & Thomas, C. W. (1997). Difficult temperament and behaviour problems: A longitudinal study from 1.5 to 12 years. *International Journal of Behavioral Development, 21,* 71-90.

Hack, M., & Fanaroff, A. A. (1999). Outcomes of children of extremely low birthweight and gestational age in the 1990's. *Early Human Development, 53,* 193-218.

Hack, M., Wilson-Costello, D., Friedman, H., Taylor, Schluchter, M., & Fanaroff, A. A. (2000). Neurodevelopmental and predictors of outcome of children with birth weights of less than 1000 g. *Archives of Pediatric and Adolescent Medicine, 154,* 725-731.

Haley, D. W., Weinberg, J., & Grunau, R. E. (2006). Cortisol, contingency learning, and memory in preterm and full-term infants. *Psychoneuroendocrinology, 31,* 108-117.

Halpern, L. F., & Garcia Coll, C. T. (2000). Temperament of small-for-gestational-age and appropriate-for-gestational-age infants across the first year of life. *Merrill-Palmer Quarterly, 46,* 738-765.

Halpern, L. F., Brand, K.L., & Malone, A. F. (2001). Parenting stress in mothers of very-low-birth-weight (VLBW) and full-term infants: A function of infant behavioral characteristics and child-rearing attitudes. *Journal of Pediatric Psychology, 26,* 93-104.

Halpern, L. F., Garcia Coll, C. T., Meyer, E. C., & Bendersky, K. (2001). The contributions of temperament and maternal responsiveness to the mental development of small-for-gestational-age and appropriate-for-gestational-age infant. *Applied Developmental Psychology, 22,* 199-224.

Hamilton, B. E., Martin, J. A.., & Sutton, P. D. (2004). Births: Preliminary data for 2003, *National Vital Statistics Reports*, 53(9). Centers for Disease Control and Prevention. Retrieved November 2, 2005, from http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_09.pdf.

Haskett, M. E., Ahern, L. S., Ward, C. S., & Allaire, J. C. (2006). Factor structure and validity of the Parenting Stress Index-Short Form. *Journal of Clinical Child and Adolescent Psychology, 35,* 302-312.

Hawdon, J. M., Hey, E., Kolvin, I., & Fundudis, T. (1990). Born too small: Is outcome still affected? *Developmental Medicine & Child Neurology, 32,* 943-953.

Hay, D. F., Pawlby, S., Sharp, D., Schmucker, G., Mills, A., Allen, H., et al. (1999). Parents' judgments about young children's problems: Why mothers and fathers might disagree yet still predict later outcomes. *Journal of Child Psychology & Psychiatry, 40,* 1249-1258.

Headley, A. J., Fulcomer, M. C., Bastardi, M. M., Wansoo, I., Sass, M. M., & Chung, C. (2006). The use of missing birth record data as a marker for adverse reproductive outcomes: A geocoded analysis of birth record data. *Journal of the American Medical Association, 98,* 1078-1088.

Hertzig, M. E., & Mittelman, M. (1984). Temperament in low birthweight children. *Merrill-Palmer Quarterly, 30,* 201-211.

Honjo, S., Mizuno, R., Sechiyama, H., Sasaki, Y., Kaneko, H., Nishide, T., et al. (2002). Temperament of low birth weight infants and child-rearing stress: Comparison with full-term healthy infants. *Early Child Development and Care, 172,* 65-75.

Horwood, L. J., Mogridge, N., & Darlow, B. A. (1998). Cognitive, educational, and behavioural outcomes at 7 to 8 years in a national very low birthweight cohort. *Archives of Disease in Childhood Fetal and Neonatal Edition, 79,* F12-F20.

Hoy, E. A., Sykes, D. H., Bill, J. M., Halliday, H. L., McClure, B. G., & McC. Reid, M. (1992). The social competence of very-low-birthweight children: Teacher, peer, and self-perceptions. *Journal of Abnormal Child Psychology, 20,* 123-150.

Huddy, C. L., Johnson, A., & Hope, P. L. (2001). Educational and behavioural problems in babies of 32-35 weeks gestation. *Archives of Disease in Childhood Fetal & Neonatal Edition, 85,* F23-F8.

Hughes, M. B., Shults, J., McGrath, J., & Medoff-Cooper, B. (2002). Temperament characteristics of premature infants in the first year of life. *Journal of Developmental and Behavioral Pediatrics, 23,* 430-435.

Hughes, C. A., O'Gorman, L. A., Shyr, Y., Schork, M. A., Bozynski, M. E., & McCormick, M. C. (1999). Cognitive performance at school age of very low birth weight infants with bronchopulmonary dysplasia. *Journal of Developmental and Behavioral Pediatrics, 20,* 1-8.

Indredavik, M. S., Skranes, J. S., Vik, T., Heyerdahl, S., Romundstad, P., Myhr, G. E. et al. (2005). Low-birth-weight adolescents: psychiatric symptoms and cerebral MRI abnormalities. *Pediatric Neurology, 33,* 259-66.

Indredavik, M. S., Vik, T., Heyerdahl, S., Kulseng, S., Fayers, P., & Brubakk, A. M. (2004). Psychiatric symptoms and disorders in adolescents with low birth weight. *Archives of Disease in Childhood Fetal and Neonatal Edition, 89,* F445-F450.

James, L. R., & Brett, J. M. (1984). Mediators, moderators, and tests for mediation. *Journal of Applied Psychology, 69,* 307-321.

Jensen, P. S., Rubio-Stipec, M., Canino, G., Bird, H. R., Dulcan, M. K., Schwab-Stone, M. E., et al. (1999). Parent and child contributions to diagnosis of mental disorder: Are both informants always necessary? *Journal of the American Academy of Child and Adolescent Psychiatry, 38,* 1569-1579.

Jobe, A. H. (2004). Postnatal corticosteroids for preterm infants – do what we say, not what we do. *New England Journal of Medicine, 350,* 1349-1351.

Keenan, K., Shaw, D., Delliquadri, E., Giovannelli, J., & Walsh, B. (1998). Evidence for the continuity of early problem behaviors: Application of a developmental model. *Journal of Abnormal Child Psychology, 26,* 441-452.

Kolko, D. J., & Kazdin, A. E. (1993). Emotional/behavioral problems in clinic and nonclinic children: Correspondence among child, parent, and teacher reports. *Journal of Child Psychology & Psychiatry, 34,* 991-1006.

Korner, A. F. (1996). Reliable individual differences in preterm infants' excitation management. *Child Development, 67,* 1793-1805.

Korner, A. F., Stevenson, D. K., Kraemer, H. C., Spiker, D., Constantinou, J., Dimiceli, S., et al. (1993). Prediction of the development of low birth weight preterm infants by a new neonatal medical index. *Journal of Developmental and Behavioral Pediatrics, 14,* 106-111.

Kramer, M. S., Goulet, L., Lydon, J., Seguin, L., McNamara, H., Dassa, C., et al. (2001). Socio-economic disparities in preterm birth: causal pathways and mechanisms. *Paediatric and Perinatal Epidemiology, 15 (Supplement 2),* 104-23.

Kruesi, M. J., Casanova, M. F., Mannheim, G., & Johnson-Bilder, A. (2004). Reduced temporal lobe volume in early onset conduct disorder. *Psychiatry Research, 132,* 1-11.

Ladd, C. O., Huot, R. L., Thrivikraman, K. V., Nemeroff, C. B., Meaney, M. J., Plotsky, P. M. (2000). Long-term behavioral and neuroendocrine adaptations to adverse early experiences. *Progress in Brain Research,122,* 81-103.

Landry S. H., Smith K. E., & Swank P. R. (2003). The importance of parenting during early childhood for school-age development. *Developmental Neuropsychology, 24,* 559-591.

Landry, S. H., Smith, K. E., Miller-Loncar, C. L., & Swank, P. R. (1997). Predicting cognitive-language and social growth curves from early maternal behaviors in children at varying degrees of biological risk. *Developmental Psychology, 33,* 1040-1053.

Landry, S. H., Smith, K. E., Swank, P. R., Assel, M. A., & Vellet, S. (2001). Does early responsive parenting have a special importance for children's development or is consistency across early childhood necessary? *Developmental Psychology, 37,* 387-403.

Langkamp, D., Kim, Y., & Pascoe, J. (1998). Temperament of preterm infants at 4 months of age: maternal ratings and perceptions. *Journal of Developmental and Behavioral Pediatrics, 19,* 391-396.

Larroque, B., Marret, S., Ancel, P. Y., Arnaud, C., Marpeau, L., Supernant, K., et al. (2003). White matter damage and intraventricular hemorrhage in very preterm infants: The Epipage Study. *Journal of Pediatrics, 143,* 477-483.

Larroque, B., Tich, S. N., Guedeney, A., Marchand, L., & Burguet, A. (2005). Temperament at 9 months of very preterm infants born at less than 29 weeks' gestation: The Epipage Study. *Developmental and Behavioral Pediatrics, 26,* 48-55.

Lee, C. M., & Gotlib, I. H. (1991). Adjustment of children of depressed mothers: A 10-month follow-up. *Journal of Abnormal Psychology, 100,* 473-477.

Lehn, H., Derks, E. M., Hudziak, J. J., Heutink, P., Van Beijsterveldt, T., & Boomsma, D. I. (2007). Attention problems and attention-deficit/hyperactivity disorder in discordant and concordant monozygotic twins: Evidence of environmental mediators. *Journal of the American Academy of Child and Adolescent Psychiatry, 46,* 83-91.

Levy-Shiff, R., Einat, G., Mogilner, M. B., Lerman, M., & Krikler, R. (1994). Biological and environmental correlates of developmental outcome of prematurely born infants in early adolescence. *Journal of Pediatric Psychology, 63-78.*

Lewis, M. D., & Stieben, J. (2004). Emotion regulation in the brain: Conceptual issues and directions for developmental research. *Child Development, 75,* 371-376.

Lindquist, B., Carlsson, G., Persson, E., & Uvebrant, P. (2006). Behavioural problems and autism in children with hydrocephalus: A population-based study. *European Child and Adolescent Psychiatry, 15,* 214-219.

Linnet, K. M. , Dalsgaard, S., Obel, C., Wisborg, K., Henriksen, T. B., Rodriguez A., et al. (2003). Maternal lifestyle factors in pregnancy risk of attention deficit hyperactivity disorder and associated behaviors: Review of the current evidence. *American Journal of Psychiatry, 160,* 1028-40.

Lumley, J. (2003). Defining the problem: The epidemiology of preterm birth. *British Journal of Obstetrics and Gynaecology, 110 (Supplement 20),* 3-7.

Maziade, M. (1989). Should adverse temperament matter to the clinician? An empirically based answer. In G. A. Kohnstamm, J. E. Bates, and M. K. Rothbart (Eds.), *Temperament in childhood* (pp. 421-435). Oxford: John Wiley & Sons.

Medoff-Cooper, B. (1986). Temperament in very low birth weight infants. *Nursing Research, 35,* 139-143.

Ment, L. R., Vohr, B., Allan, W., Katz, K. H., Schneider, K. C., Westerveld, M. et al. (2003). Change in cognitive function over time in very low-birth-weight infants. *Journal of the American Medical Association, 289,* 705-711.

McCormick, M. C. (1997). The outcomes of very low birth weight infants: are we asking the right questions? *Pediatrics, 99,* 869-877.

McGauhey, P. J., Starfield, B., Alexander, C., & Ensminger, M. E. (1991). Social environmental and vulnerability of low birth weight children: A social-epidemiological perspective. *Pediatrics, 88,* 943-952.

Miceli, P. J., Goeke-Morey, M. C., Whitman, T. L., Kolberg, K. S., Miller-Loncar, C. & White, R. D. (2000). Brief report: Birth weight, medical complications, and social environment: individual differences in development of preterm, very low birth weight infants. *Journal of Pediatric Psychology, 25,* 353-8.

Mick, E., Beiderman, J., Prince, J., Fischer, M. J., & Faraone, S. V. (2002). Impact of low birth weight on attention-deficit hyperactivity disorder. *Journal of Developmental and Behavioral Pediatrics, 23,* 16-23.

Miles, M. S., Holditch-Davis, D., Schwartz, T. A., & Scher, M. (2007). Depressive symptoms in mothers of prematurely born infants. *Journal of Developmental and Behavioral Pediatrics, 28,* 36-44.

Miller, M., Bowen, J. R., Gibson, F. L., Hand, P. J., & Ungerer, J. A. (2001). Behaviour problems in extremely low birthweight children at 5 and 8 years of age. *Child: Care, Health and Development, 27,* 569-581.

Missouri Department of Health State Center for Health Statistics. (1994). Preliminary results from the VLBW study. *Missouri Monthly Vital Statistics, 28 (3).*

Moore, M., Taylor, G., Klein, N., Minich, N., & Hack, M. (2006). Longitudinal changes in family outcome of very low birth weight. *Journal of Pediatric Psychology, 31,* 1024-1035.

Morris, B. H., Smith, K. E., Swank, P. R., Denson, S. E., & Landry, S. H. (2002). Patterns of physical and neurologic development in preterm children. *Journal of Perinatology, 22,* 31-37.

Morris, A. S., Silk, J. S., Steinberg, L., Sessa, F. M., Avenevoli, S., & Essex, M. J. (2002). Temperamental vulnerability and negative parenting as interacting predictors of child adjustment. *Journal of Marriage and Family, 64,* 461-471.

Muller, D., Judd, C. M., & Yzerbyt, V. Y. (2005). When moderation is mediated and mediation is moderated. *Journal of Personality and Social Psychology, 89,* 852-863.

Myers, B. J., Jarvis, P. A., Creasey, G. L., Kerkering, K. W., Markowitz, P. I., & Best, A. M. (1992). Prematurity and respiratory illness: Brazelton scale (NBAS) performance of preterm infants with bronchopulmonary dysplasia (BPD), respiratory distress syndrome (RDS), or no respiratory illness. *Infant Behavior and Development, 15,* 27-41.

Nadeau, L., Boivin, M., Tessier, R., Lefebvre, F., & Robaey, P. (2003). Mediators of behavioral problems in 7-year-old children born after 24 to 28 weeks of gestation. *Journal of Developmental and Behavioral Pediatrics, 22,* 1-10.

Nadeau, L., Tessier, R., Boivin, M., Lefebvre, F., & Robaey, P. (2001). Extremely premature and very low birthweight infants: A double hazard population? *Social Development, 12,* 235-248.

Najman, J. M., Williams, G. M., Nikles, J., Spence, S., Bor, W., O'Callaghan, M., et al. (2000). Mothers' mental illness and child behavior problems: Cause-effect association or observation bias? *Journal of the American Academy of Child & Adolescent Psychiatry, 39,* 592-602.

National Center for Health Statistics. (2004). Final Natality Data prepared by March of Dimes Perinatal Data Center.

Nelson, C. A. (1994). Neural bases of infant temperament. In J. E. Bates and T. D. Wachs, Theodore (Eds.), *Temperament: Individual differences at the interface of biology and behavior* (pp. 47-82). Washington, DC: American Psychological Association.

Newman, D. G., O'Callaghan, M. J., Harvey, J. M., Tudehope, D. I., Gray, P. H., Burns, Y. R., et al. (1997). Characteristics at four months follow-up for infants born small for gestational age: A controlled study. *Early Human Development, 49,* 169-181.

NICHD Early Child Care Research Network. (1999). Chronicity of maternal depressive symptoms, maternal sensitivity and child functioning at 36 months. *Developmental Psychology, 35,* 1297-1310.

Nigg, J. T., & Breslau, N. (2007). Prenatal smoking exposure, low birth weight, and disruptive behavior disorders. *Journal of the American Academy of Child and Adolescent Psychiatry, 46,* 362-369.

Oberklaid, F., Prior, M., & Sanson, A. (1986). Temperament of preterm versus full-term infants. *Journal of Developmental & Behavioral Pediatrics, 7,* 159-162.

Oberklaid, F., Sewell, J., Sanson, A., & Prior, M. (1991). Temperament and behavior of preterm infants: A six-year follow-up. *Pediatrics, 87,* 854-861.

Olson, S. L., Bates, J. E., Sandy, J. M., & Shilling, E. M. (2002). Early developmental precursors of impulsive and inattentive behavior: from infancy to middle childhood. *Journal of Child Psychology and Psychiatry, 43,* 435-447.

Paneth, N. (1995). The problem of low birth weight. *The Future of Children, 5,* 19-34.

Paterson, G., & Sanson, A. (1999). The association of behavioral adjustment to temperament, parenting, and family characteristics among 5-year-old children. *Social Development, 8,* 293-309.

Patton, G. E., Coffey, C., Carlin, J. B., Olsson, C. A., & Morley, R. (2004). Prematurity at birth and adolescent depressive disorder. *British Journal of Psychiatry, 184,* 446-447.

Pearlin, L. I., Menaghan, E. G., Lieberman, M. A., & Mullan, J. T. (1981). The stress process. *Journal of Health and Social Behavior, 22,* 337-356.

Pederson, D. R., Bento, S., Chance, G. W., Evans, B., & Fox, A. M. (1987). Maternal emotional responses to preterm birth. *American Journal of Orthopsychiatry, 57,* 15-21.

Pennington, B.F. (2001). Genetic methods. In C.A. Nelson and M. Luciana (Eds.), *Handbook of developmental cognitive neuroscience* (pp.149-158). Cambridge, MA: MIT Press.

Petrou, S. (2003). Economic consequences of preterm birth and low birthweight. *British Journal of Obstetrics and Gynaecology, 110 (Supplement 20),* 17-23.

Petrou, S., Henderson, J., Bracewell, M., Hockley, C., Wolke, D. & Marlow, N. (2006). Pushing the boundaries of viability: The economic impact of extreme preterm birth. *Early Human Development, 82,* 77-84.

Pharoah, P., Stevenson, C. J., Cooke, R., & Stevenson, R. C. (1994). Prevalence of behavior disorders in low birthweight infants. *Archives of Diseases in Childhood, 70,* 271-274.

Plomin, R. (1994). *Genetics and experience: The developmental interface between nature and nurture*. Newbury Park, CA: Sage.

Posner, M. I., & Petersen, S. E. (1990). The attention system of the human brain. *Annual Review of Neuroscience, 13,* 25-42.

Preacher, K. J., Rucker, D. D., & Hayes, A. F. Suggested procedures for assessing moderated mediation hypotheses. Retrieved December 2, 2005 from http://www.geocities.com/quantpsy/prh05abs.htm.

Prior, M., Smart, D., Sanson, A., & Oberklaid, F. (2001). Longitudinal predictors of behavioural adjustment in pre-adolescent children. *Australian and New Zealand Journal of Psychiatry, 35,* 297-307.

Pryce, C. R., & Feldon, J. (2003). Long-term neurobehavioural impact of the postnatal environment in rats: Manipulations, effects and mediating mechanisms. *Neuroscience Biobehavioral Review, 27,* 57-71.

Radloff, L. S. (1977). The CES-D Scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement, 1,* 385-401.

Radloff, L. S. (1991). The use of the Center for Epidemiologic Studies Depression Scale in adolescents and young adults. *Journal of Youth and Adolescence, 20,* 149-166.

Rapee, R. M. (2001). The development of generalized anxiety. In M. W. Vasey and M. R. Dadds (Eds.), *The developmental psychopathology of anxiety* (pp. 481-503). New York: Oxford University Press.

Raine, A. (2002). Annotation: The role of prefrontal deficits, low autonomic arousal, and early health factors in the development of antisocial and aggressive behavior in children. *Journal of Child Psychology and Psychiatry, 43,* 417-434.

Reijneveld, S. A., de Kleine, M. J. K., van Baar, A. L., Kollee, L. A. A., Verhaak, C. M., Verhulst, F. C. et al. (2006). Behavioural and emotional problems in very preterm and very low birth weight infants at age 5 years. *Archives of Disease in Childhood Fetal and Neonatal Edition, 91,* F423-428.

Ren, K., Anseloni, V., Zou, S. P., Wade, E. B., Novikova, S. I., Ennis, M. et al. (2004). Characterization of basal and reinflammation-associated long-term alternation in pain responsivity following short-lasting neonatal local inflammatory insult. *Pain, 110,* 588-596.

Repetti, R. L., Taylor, S. E., & Seeman, T. E. (2002). Risky families: Family social environments and the mental and physical health of offspring. *Psychological Bulletin, 128,* 330-366.

Riese M. L. (1994). Neonatal temperament in full-term twin pairs discordant for birth weight. *Journal of Developmental & Behavioral Pediatrics, 15,* 342-7.

Robson, A., & Cline, B. (1998). Developmental consequences of intrauterine growth retardation. *Infant Behavior and Development, 21,* 331-344.

Rosenberg, M. (1989). *Society and the Adolescent Self-Image- Revised Edition.* Middletown, CT: Wesleyan University Press.

Ross, G. (1987). Temperament in preterm infants: its relationship to perinatal factors and one-year outcome. *Journal of Developmental and Behavioral Pediatrics, 8,* 106-110.

Ross, G., Lipper, E., & Auld, P. A. M. (1990). Social competence and behavior problems in premature children at school age. *Pediatrics, 86,* 391-397.

Ross, G., Boatright, S., Auld, P. A. M., & Nass, R. (1996). Specific cognitive abilities in 2-year-old children with subependymal and mild intraventricular hemorrhage. *Brain and Cognition, 32,* 1-13.

Ross, G., Tesman, J., Auld, P. A. M., & Nass, R. (1992). Effects of subependymal and mild intraventricular lesions on visual attention and memory in premature infants. *Developmental Psychology, 28,* 1067-1074.

Rosso, I. M., Cintron, C. M., Steingard, R. J., Renshaw, P. F., Young, A. D., & Yurgelun-Todd, D. A. (2005). Amygdala and hippocampus volumes in pediatric major depression. Biological Psychiatry, 57, :21-26.

Rothbart, M. K., & Bates, J. E. Temperament. (1998). In W. Damon and N. Eisenberg (Eds.), *Handbook of child psychology, 5th ed.: Vol 3. Social, emotional, and personality development* (pp. 105-176). Hoboken, NJ: John Wiley & Sons, Inc.

Rothbart, M. K., Derryberry, D., & Posner, M. I. (1994). A psychobiological approach to the development of temperament. In J. E. Bates and T. D. Wachs, Theodore (Eds.), *Temperament: Individual differences at the interface of biology and behavior* (pp. 83-116). Washington, DC: American Psychological Association.

Rubin, K. H., Burgess, K. B., & Hastings, P. D. (2002). Stability and social-behavioral consequences of toddlers' inhibited temperament and parenting behaviors. *Child Development, 73*, 483-495.

Rubin, K. H., Hastings, P., Chen, X., Stewart, S., & McNichol, K. (1998). Intrapersonal and maternal correlates of aggression, conflict, and externalizing problems in toddlers. *Child Development, 69,* 1614-1629.

Rubin, K. H., Nelson, L. J., Hastings, P., & Asendorpf, J. (1999). The transaction between parents' perceptions of their children's shyness and their parenting styles. *International Journal of Behavioral Development, 23*, 937-957.

Saigal, S. (1999). Maternal psychological distress and parenting stress after the birth of a very low-birth-weight infant. *Journal of Pediatrics, 135,* 397.

Saigal, S., Pinelli, J., Hoult, L., Kim, M. M., & Boyle, M. (2003). Psychopathology and social competencies of adolescents who were born extremely low birth weight. *Pediatrics, 111,* 969-975.

Sajaniemi, N., Salokorpi, T., & von Wendt, L. (1998). Temperament profiles and their role in neurodevelopmental assessed preterm children at two years of age. *European Child and Adolescent Psychiatry, 7,* 145-152.

Scher, M. S., Steppe, D. A., & Banks, D. L. (1996). Prediction of lower developmental performances of healthy neonates by neonatal EEG-sleep measures. *Pediatric Neurology, 14,* 137-144.

Schothorst, P. F., & van Engeland, H. (1996). Long-term behavioral sequalae of prematurity. *Journal of the American Academy of Child & Adolescent Psychiatry, 35,* 175-183.

Sherlock, R. L., Anderson, P. J., & Doyle, L. W. (2005). Neurodevelopmental sequalae of intraventricular hemorrhage at 8 years of age in a regional cohort of ELBW/very preterm infants. *Early Human Development, 81,* 909-916.

Shinwell, E. S. (2005). Neonatal morbidity of very low birth weight infants from multiple pregnancies. *Obstetrics & Gynecology Clinics of North America, 32,* 29-38.

Singer, L., Arendt, R., Farkas, K., Minnes, S., Huang, J., & Yamashita, T. (1997). Relationship of prenatal cocaine exposure and maternal postpartum psychological distress to child developmental outcome. *Development and Psychopathology, 9,* 473-489.

Singer, L. T., Fulton, S., Davillier, M., Koshy, D., Salvator, A., & Baley, J. E. (2003). Effects of infant risk status and maternal psychological distress on maternal-infant interactions during the first year of life. *Journal of Developmental & Behavioral Pediatrics, 24,* 233-241.

Singer, L. T., Salvator, A., Guo, S., Collin, M., Lilien, L., & Baley, J. (1999). Maternal psychological distress and parenting stress after the birth of a very-low-birth-weight infant. *Journal of the American Medical Association, 281,* 799-805.

Sobel, M. E. (1988). Direct and indirect effects in linear structural equation models. In J. S. Long (Ed.), Common problems/proper solutions: Avoiding error in quantitative research (pp. 46-64). Beverly Hills, CA: Sage.

Sommerfelt, K., Troland, K., Ellertsen, B., & Markestad, T. (1996). Behavioral problems in low birthweight preschoolers. *Developmental Medicine and Child Neurology, 38,* 927-940.

Spungen, L. B., & Farren, A. C. (1986). Effect of intensive care unit exposure on temperament in low birth weight preterm infants. *Journal of Developmental and Behavioral Pediatrics, 7,* 288-292.

Stern, M., Karraker, K., McIntosh, B., Moritzen, S., & Olexa, M. (2006). Prematurity stereotyping and mothers' interactions with their premature and full-term infants during the first year. *Journal of Pediatric Psychology, 31,* 597-607.

Stevenson, C. J., Blackburn, P., & Pharoah, P.O.D. (1999). Longitudinal study of behaviour disorders in low birthweight infants. *Archives of Disease in Childhood Fetal and Neonatal Edition, 81,* F5-F9.

Stevenson, D. K., Wright, L. L., Lemons, J. A., Oh, W., Korones, S. B., Papile, L., et al. (1998). Very low birth weight outcomes of the National Institute of Child Health and Human Development Neonatal Research Network, January 1993 through December 1994. *American Journal of Obstetrics and Gynecology, 179,* 1632-1639.

Stiefel, G. S., Plunkett, J. W., & Meisels, S. J. (1987). Affective expression among preterm infants of varying levels of biological risk. *Infant Behavior and Development, 10,* 151-164.

Stoelhorst, G., Rijken, M., Martens, S. E., van Zwieten, P., Feenstra, J., Zwinderman, A. H et al. (2003). Developmental outcomes at 18 and 24 months of age in very preterm children: A cohort study. *Early Human Development, 72,* 83-95.

Swaminathan, S., Alexander, G. R., & Boulet, S. (2006). Delivering a very low birth weight infant and the subsequent risk of divorce or separation. *Maternal and Child Health Journal, 10,* 473-479.

Sweet, M. P., Hodgman, J. E., Pena, I., Barton , L., Pavlova., Z. & Ramanathan, R. (2003). Two-year outcome of infants weighing 600 grams or less at birth and born 1994 through 1998. *Obstetrics & Gynecology, 101,* 18-23.

Sykes, D. H., Hoy, E. A., Bill, J. M., McClure, B. G., Halliday, H. L., & Reid, M. M. (1997). Behavioural adjustment in school of very low birthweight children. *Journal of Child Psychology & Psychiatry, 38,* 315-325.

Szatmari, P., Saigal, S., Rosenbaum, P., Campbell, D., & King, S. (1990). Psychiatric disorders at five years among children with birthweights <1000g: A regional perspective. *Developmental Medicine & Child Neurology, 32,* 954-962.

Taylor, H. G., Klein, N., & Hack, M. (2000). School-age consequences of birth weight less than 750 g: A review an update. *Developmental Neuropsychology, 17,* 289-321.

Taylor, H. G., Klein, N., Drotar, D., Schluchter, M., & Hack, M. (2006). Consequences and risks of <1000-g birth weight for neuropsychological skills, achievement, and adaptive functioning. *Journal of Developmental and Behavioral Pediatrics, 27,* 459-469.

Taylor, H. G., Klein, N., Minich, N. M., & Hack, M. (2000). Middle school-age outcomes in children with <750 g birthweight. *Child Development, 71,* 1495-1511.

Taylor, H. G., Klein, N., Schatschineider, C., & Hack, M. (1998). Predictors of early school age outcomes in very low birth weight children. *Developmental and Behavioral Pediatrics, 19,* 235-243.

Thomas, A., & Chess, S. (1977). *Temperament and development.* New York: Brunner/Mazel.

Thompson, R. J., Oehler, J. M., Catlett, A. T., & Johndrow, D. A. (1993). Maternal psychological adjustment to the birth of an infant weighing 1,500 grams or less. *Infant Behavior and Development, 16,* 471-485.

Thompson, C., Syddall, H., Rodin, I., Osmond, C., Barker, D. J. P. (2001). Birth weight and the risk of depressive disorder in late life. *British Journal of Psychiatry, 179,* 450-455.

Tommiska, V., Ostberg, M., & Fellman, V. (2002). Parental stress in families of 2 year old extremely low birthweight infants. *Archives of Disease in Childhood Fetal and Neonatal Edition, 86,* F161-F165.

Treutler, C. M., & Epkins, C. C. (2003). Are discrepancies among child, mother, and father reports on children's behavior related to parents' psychological symptoms and aspects of parent-child relationships? *Journal of Abnormal Child Psychology, 31,* 13-27.

Turecki, S. (1995). Temperamentally difficult children. In S. Parker, and B. Zuckerman (Eds.), *Behavioral and developmental pediatrics* (pp. 310-314). Boston: Little, Brown.

Tyson, J. E., & Broyles, R. S. (1996). Progress in assessing the long-term outcome of extremely low-birth-weight infants. *Journal of the American Medical Association, 276,* 492-495.

van Beek, Y., Hopkins, B., & Hoeksma, J. (1994). Development of communicative behaviors in preterm infants: The effects of birthweight status and gestational age. *Infant Behavior & Development, 17,* 107-117.

Vohr, B. R., Wright, L. L., Dusick, A. M., Mele, L., Verter, J., Steichen, J. J. et al. (2000). Neurodevelopmental and functional outcomes of extremely low birth weight infants in the National Institute of Child Health and Human Development Neonatal Research Network, 1993-1994. *Pediatrics, 105,* 1216-1226.

Vollmer, B., Roth, S., Rilet, K., O'Brian, F., Baudin, J., De Haan, M. et al. (2006). Long-term neurodevelopmental outcome of preterm children with unilateral cerebral lesions diagnosed by neonatal ultrasound. *Early Human Development, 82,* 655-661.

Wallace, I. F., & McCarton, C. M. (1997). Neurodevelopmental outcomes of the premature, small-for-gestational-age infant through age 6. *Clinical Obstetrics and Gynecology, 40,* 843-852.

Walther, F. J., den Ouden, A. L., & Verloove-Vanhorick, S. P. (2000). Looking back in time: Outcome of a national cohort of very preterm infants born in The Netherlands in 1983. *Early Human Development, 59,* 175-191.

Ward, R. M., & Beachy, J. C. (2003). Neonatal complications following preterm birth. *British Journal of Obstetrics & Gynaecology, 110 (Supplement 20),* 8-16.

Watt, J. (1987). Temperament in small-for-dates and pre-term infants: A preliminary study. *Child Psychiatry and Human Development, 17,* 177-188.

Weindrich, D., Jennen-Steinmetz, C., Laucht, M., & Schmidt, M. H. (2003). Late sequelae of low birthweight: Mediators of poor school performance at 11 years. *Developmental Medicine & Child Neurology, 45,* 463-469.

Weisglas-Kuperus, N., Koot, H., Baerts, W., Fetter, W. P. F., & Sauer, P. J. J. (1993). Behaviour problems of very low birthweight children. *Developmental Medicine and Child Neurology, 35,* 406-416.

Weiss, S. J., St. Jonn-Seed, M., & Wilson, P. (2004). The temperament of pre-term, low birth weight infants and its potential biological substrates. *Research in Nursing & Health, 27,* 392-402.

Werner, E. E., Bierman, J. M., & French, F. E. (1971). *The children of Kauai: A longitudinal study from the prenatal period to age ten.* Honolulu: University of Hawaii Press.

Whitaker, A. H., Van Rossem, R., Feldman, J. F., Schonfeld, I. S. Pinto-Martin, J. A., Torre, C., et al. (1997). Psychiatric outcomes in low-birth-weight children at age 6 years: Relation to neonatal cranial ultrasound abnormalities. *Archives of General Psychiatry, 54,* 847-856.

Whitfield, M. F., Grunau, R. V., & Holsti, L. (1997). Extremely premature (< or = 800 g) schoolchildren: Multiple areas of hidden disability. *Archives of Disease in Childhood Fetal & Neonatal Edition, 77,* F85-F90.

Wildrick, D. (1997). Intraventricular hemorrhage and long-term outcome in the premature infant. *Journal of Neuroscience Nursing, 29,* 281-290.

Wocadlo, C., & Rieger, I. (2006). Social skills and nonverbal decoding of emotions in very preterm children at early school age. *European Journal of Developmental Psychology, 3,* 48-70.

Yeh, T. F., Lin, Y. J., Lin, H. C., Huang, C. C., Hsieh, W. S., Lin, C. H., et al. (2004). Outcomes at school age after postnatal dexamethasone therapy for lung disease of prematurity. *New England Journal of Medicine, 350,* 1304-1313.

Youngstrom, E., Loeber, R., & Stouthamer-Loeber, M. (2000). Patterns and correlates of agreement between parent, teacher, and male adolescent ratings of externalizing and internalizing problems. *Journal of Consulting and Clinical Psychology, 68,* 1038-1050.

Footnotes

1. The most recent report from the CDC regarding births in the United States indicated a decrease from previous years in the number of women who reported smoking cigarettes during pregnancy, as well as a decrease in the numbers of births to adolescents in all age and race/ethnicity groups. In addition, the percentage of women who received timely prenatal care continued to rise, a trend that has been observed since the early 1990s (National Center for Health Statistics, 2004).

2. Common neurodevelopmental problems noted in infancy include cerebral palsy, blindness and hearing loss, seizures, and shunt dependent hydrocephalus (Doyle, 2001; Hack et al., 2000; Vohr et al., 2000). Low birth weight is also associated with poorer performance across a variety of tasks during infancy and toddlerhood, including those assessing motor skills, memory, expressive language skills, social initiation, and habituation and novelty preference (Landry, Smith, Miller-Loncar, & Swank, 1997; Ross, Boatright, Auld, & Nass, 1996; Ross, Tesman, Auld, & Nass, 1992). Studies examining the effect of low birth weight on cognitive outcomes in childhood and adolescence report higher rates of problems in school achievement, problems with executive function, reading and math skills, memory, and lower visual-motor skill in low birth weight populations compared with normal birth weight controls (Boehm, Katz-Salamon, Smedler, Langercrantz, & Forssberg, 2002; Anderson & Doyle, 2003).

3. There is considerable debate about whether birth weight is best measured by weight at birth or gestational age. Traditionally, studies in this area have defined groups using only birth weight. However, it has been noted that due to intrauterine growth retardation (IUGR), birth weight classifications often consist of diverse groups of low birth weight

infants, including those who are both preterm and small for gestational age (i.e., birth weight at less than the 10th percentile for gestational age, often due to), and older preterm or full-term infants who are extremely small for gestational age (i.e., birth weight at less than the 3rd percentile for gestational age) (Touwen, 1986). This heterogeneity has led some to conclude that distinguishing between infants based on weight at birth obscures important differences among children with respect to organ/system development and risk for subsequent morbidity (Aylward, 2002; McCormick, 1997; Tyson & Broyles, 1996). Classification according to gestational age has been proposed as an alternative that would result in the creation of more homogenous groups of infants with similar profiles of biological and psychosocial risk (Girouard et al., 1998).

Although this argument is compelling, a significant portion of research in this area has continued to focus on the relation of low birth weight rather than gestational age to estimates of mortality and morbidity. In their review of research focusing on school-age consequences in children born extremely low birth weight, Taylor and colleagues suggest three reasons for this trend (Taylor, Klein, & Hack, 2000). First, data suggest that preterm delivery rather than IUGR accounts for the majority of low birth weight in the United States. Consequently, for the majority of children in this population, gestational age and birth weight are highly related and similarly predict outcomes. Second, difficulties in the accurate determination of gestational age may complicate the classification of infants into unique groups. Although this is less of a problem in recent years, studies may still differ with respect to their measurement of gestational age. For example, gestational age is often first measured as number of completed weeks since last menstrual period, and later measured using early ultrasound assessments. Although

ultrasound measures are typically more accurate, they are not always available. Finally, although sparse, some data suggest that IUGR does not exert a significant effect on outcomes above the variance accounted for by low birth weight.

4. Our exploratory analyses testing alternative moderated mediation models for toddler outcomes provided evidence of a small but significant moderating effect for maternal depression. Specifically, our findings suggested that maternal depression interacted with birth weight to affect the severity of infant medical complications at birth (Figure 6). This result should be interpreted cautiously, as maternal depression was measured when infants were 9 months of age. One explanation is that mothers who were depressed at that T1 assessment were also depressed in the perinatal period. Additional work is needed to examine the possible adverse effect of maternal depression on infant health status at birth.

Table 1. *Study 1 Sample Characteristics (ECLS-B)*

Variable	*n*	Weighted %
Child biological sex		
Boy	4651	51.06
Girl	4423	48.94
Child's race/ethnicity*		
Caucasian, non-Hispanic	3715	54.65
African American, non-Hispanic	1412	13.26
Hispanic	1295	16.49
Other racial or ethnic minority	2614	15.61
Maternal marital status (T1)		
Married	5913	67.17
Not married	3149	32.83
Maternal education level (T1)		
Less than high school	2366	26.45
High school degree	1902	21.26
Some college/college degree	2362	27.03
Some graduate school/graduate degree	26.46	25.26
Prenatal cigarette exposure		
Yes	1028	10.92
No	8036	89.08

Note. $N = 9074$.

Table 2. *Study 1 Means, Standard Deviations, and Zero-Order Correlations Among Study Variables (ECLS-B)*

Variable	1	2	3	4	5	6	7	8	9	10
1. Child sex [a]	-	.01	-.01	.02	-.09***	-.01*	-.01	-.07***	.07***	-.15***
2. Marital status [b]		-	-.42***	.17***	-.11***	.06**	.18***	.13***	-.02**	.12***
3. Maternal educational attainment [c]			-	-.21***	.07***	-.01[†]	-.16***	-.15***	.06***	-.15***
4. Prenatal cigarette exposure [d]				-	-.10***	.06[†]	.12***	.05**	-.01	.06***
5. Birth weight (grams)					-	-.69***	-.05***	-.09***	.08***	-.14***
6. Neonatal medical complications						-	.05***	.08**	-.06*	.13***
7. Maternal depression							-	.17***	-.03[†]	.08***
8. Regulatory difficulties								-	-.15***	.29***
9. Positive affect/sociable									-	-.63***
10. Negative affect/low engagement										-
M (weighted)	-	-	-	-	3334.28	-.25	4.89	-.20	11.10	17.51
SD	-	-	-	-	878.21	.85	5.48	4.17	2.68	6.10

Note. Listwise deletion was used for computing correlations among study variables. *Ns* ranged from 8457 to 9074. [a] 1= Boy and 2 = Girl. [b] 1= Married and 2 = Not married. [c] 1 = Less than high school, 2 = High school diploma or equalivent, 3 = Some college or college degree, and 4 = Graduate school or degree. [d] 0 = Not exposed and 1 = Exposed. *$p < .05$. **$p < .01$. ***$p < .001$. [†] < . 10.

Table 3. *Study 1 Summary of Regression Analyses Examining the Mediational Role of Neonatal Medical Complications in the Prediction of Children's Outcomes from Birth Weight (ECLS-B)*

(Step) Predictor	Neonatal Medical Complications	Regulatory Difficulties	Positive Affect/ Sociable	Negative Affect/ Low Engagement
(1) Child biological sex [a]	-.06***	-.07***	.08***	-.17***
(1) Race/Ethnicity [b]				
White vs. Black	-.02	.07***	.05*	.02
White vs. Hispanic	-.05***	.00	-.02	.04*
White vs. other racial/ethnic minority	-.03**	.03*	-.04*	.03[†]
(1) Maternal marital status [c]	.00	.04**	-.02	.06***
(1) Maternal educational achievement [d]	-.01	-.12***	.06**	-.09***
(1) Prenatal cigarette exposure [e]	-.02	.02	.00	.04*
(1) Birth weight	-.39***	-.03**	.06***	-.07***
(2) Neonatal medical complications	-	.02	-.01	.03*

Note. Standardized regression coefficients reported. Tests of statistical significance were obtained from regression procedures that control for design characteristics of the sample. Neonatal medical complications served as the criterion variable for one regression in order to test the first condition necessary to establish mediation (i.e., there is a significant association between the predictor and mediator). [a] 1= Boy and 2 = Girl. [b] Race/ethnicity dummy codes use White as the referent group. [c] 1= Married and 2 = Not married. [d] 1 = Less than high school, 2 = High school diploma or equalivent, 3 = Some college or college degree, and 4 = Graduate school or degree. [e] 0 = Not exposed and 1 = Exposed. *$p < .05$. **$p < .01$. ***$p < .001$. [†] < . 10.

Table 4.

Study 2 Sample Characteristics (MMIHS)

Variable	*n*	%
Child biological sex		
Boy	370	47.99
Girl	401	52.01
Child's race/ethnicity		
Caucasian, non-Hispanic	553	71.73
Racial or ethnic minority[a]	218	28.27
Maternal marital status (T1)		
Married	485	62.91
Not married	286	37.09
Maternal education level (T1)		
Less than high school	154	19.97
High school degree	304	39.43
Some college/college degree	270	35.02
Some graduate school/graduate degree	43	5.58
Prenatal cigarette exposure		
Yes	230	29.83
No	541	70.17

Note: N = 771. [a]Racial or ethnic minority category was 95.8% African American

Table 5. *Study 2 Means, Standard Deviations, and Zero-Order Correlations Among Study Variables (MMIHS)*

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Child sex [a]	-	-.03	.00	.00	.00	-.05	-.05	-.05	.10**	.07*	.07*	.06	-.05	.07*	-.05
2. Race/ethnicity		-	.49***	-.14**	.09*	-.00	-.05	.00	.00	-.02	.00	-.05	.11**	-.06	-.00
3. Marital status [b]			-	-.38**	-.17**	-.12**	.07*	.17***	.06	.10**	.05	.08*	.07*	.05	.07*
4. Maternal education[c]				-	.20**	.10**	-.03	-.30**	-.09*	-.13**	-.12**	-.17**	-.08*	-.10**	-.12**
5. Prenatal cigarette exposure [d]					-	.11**	.00	-.19**	-.10**	-.10**	-.12**	-.17**	-.07†	-.03	-.05
6. Birth weight						-	-.74**	-.09*	-.18**	-.20**	-.12**	-.12**	-.09**	-.10**	-.13**
7. Neonatal medical complications							-	.02	.16***	.19***	.08*	.08*	.10**	.09*	.17***
8. Psychological functioning								-	.08*	.13***	.14***	.20***	.06†	.17***	.17***
9. Anxious/shy									-	.32***	.34***	.29***	.41***	.39***	.43***
10. Cognitive problems/ inattention										-	.62***	.60***	.14***	.37***	.54***
11. Hyperactivity											-	.66***	.33***	.33***	.47***
12. Oppositional												-	.33***	.42***	.55***
13. Perfectionism													-	.23***	.27***
14. Psychosomatic														-	.40***

15. Social problems										-
M	2292.39	.05	40.34	51.15	52.53	53.36	50.89	49.29	53.44	50.98
SD	982.62	.87	10.42	10.35	10.87	11.34	10.04	8.91	11.67	9.59

Note. $N = 771$. [a] 1= Boy and 2 = Girl. [b] 1= Married and 2 = Not married. [c] 1 = Less than high school, 2 = High school diploma or equalivent, 3 = Some college or college degree, and 4 = Graduate school or degree. [d] 1 = Exposed and 2 = Not exposed. *$p < .05$. **$p < .01$. ***$p < .001$. [†] < . 10.

Table 6

Study 2 Summary of Regression Analyses Examining the Mediational Role of Neonatal Medical Complications in the Prediction of Children's Outcomes from Birth Weight (MMIHS)

(Step) Predictor	Neonatal medical complications	Anxious/ shy	Cognitive problems/ inattention	Hyperactivity	Oppositional	Perfectionism	Psychosomatic	Social problems
(1) Child sex [a]	-.10***	.09**	-.08*	.05	.07†	-.03	.03	-.02
(1) Race/Ethnicity [b]	-.08**	.02	-.03	.01	-.07	.13**	-.09*	-.02
(1) Maternal marital status [c]	.05	-.01	.08†	-.02	.05	-.03	.08†	.05
(1) Maternal education[d]	.05†	-.05	-.06	-.09*	-.14***	-.04	-.08*	-.11**
(1) Prenatal cigarette exposure [e]	.11***	-.07†	-.05	-.10*	-.12**	-.06	.01	-.00
(1) Birth weight	-.75***	-.16***	-.18***	-.10**	-.08*	-.09*	-.08*	-.12**
(2) Neonatal medical complications	n/a	.13*	.13*	.04	.03	.12*	.05	.19***

Note. $N = 771$. Standardized regression coefficients reported. Neonatal medical complications served as the criterion variable for one regression in order to test the first condition necessary to establish mediation (i.e., there is a significant association between the predictor and mediator). [a] 1= Boy and 2 = Girl. [b] 1 = Caucasian, non-Hispanic and 2 = Racial or ethnic minority. [c] 1= Married and 2 = Not married. [d] 1 = Less than high school, 2 = High school diploma or equalivent, 3 = Some college or college degree, and 4 = Graduate school or degree. [e] 0 = Not exposed and 1 = Exposed. *$p < .05$. **$p < .01$. ***$p < .001$. † < . 10.

Figure 1

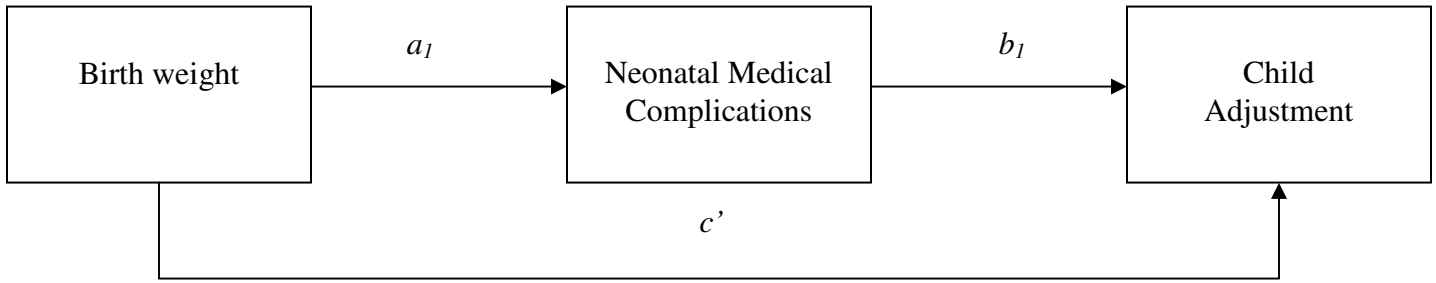

Birth weight
a_1
Neonatal Medical Complications
b_1
Child Adjustment
c'

Figure 2

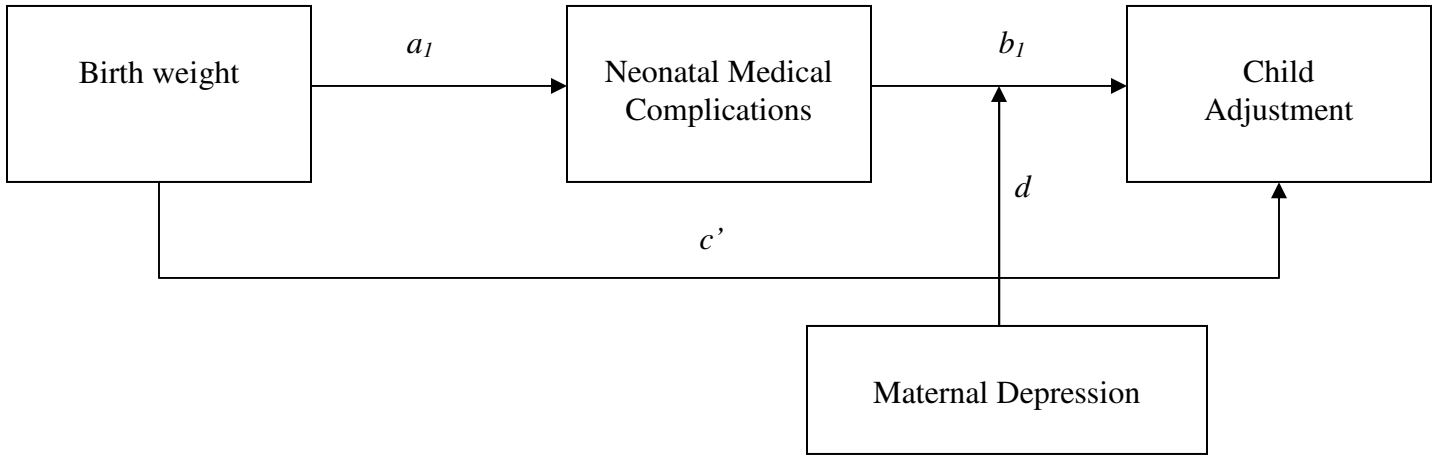

Birth weight
a_1
Neonatal Medical Complications
b_1
Child Adjustment
d
c'
Maternal Depression

Figure 3

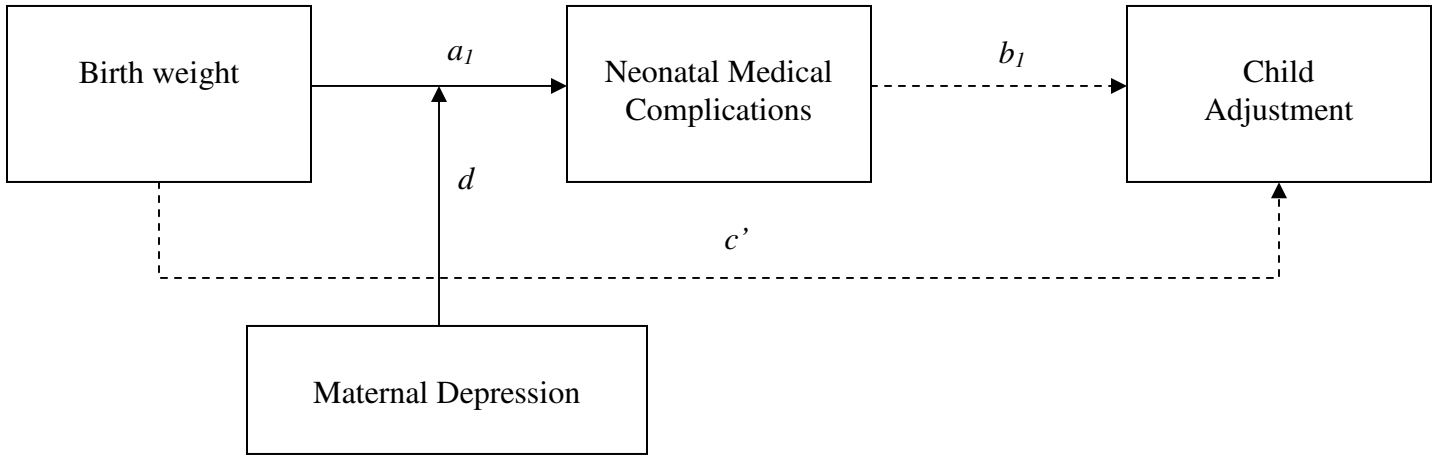

Birth weight
a_1
Neonatal Medical Complications
b_1
Child Adjustment
d
c'
Maternal Depression

Figure 4

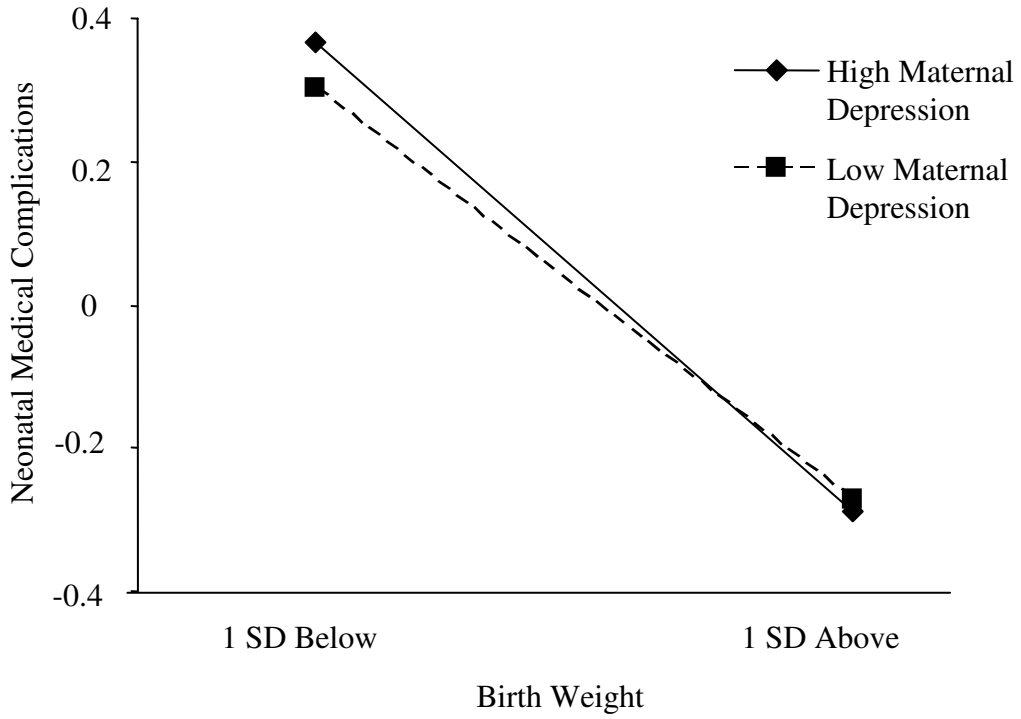

0.4
0.2
0
-0.2
-0.4
Neonatal Medical Complications
High Maternal Depression
Low Maternal Depression
1 SD Below
1 SD Above
Birth Weight

Figure 5

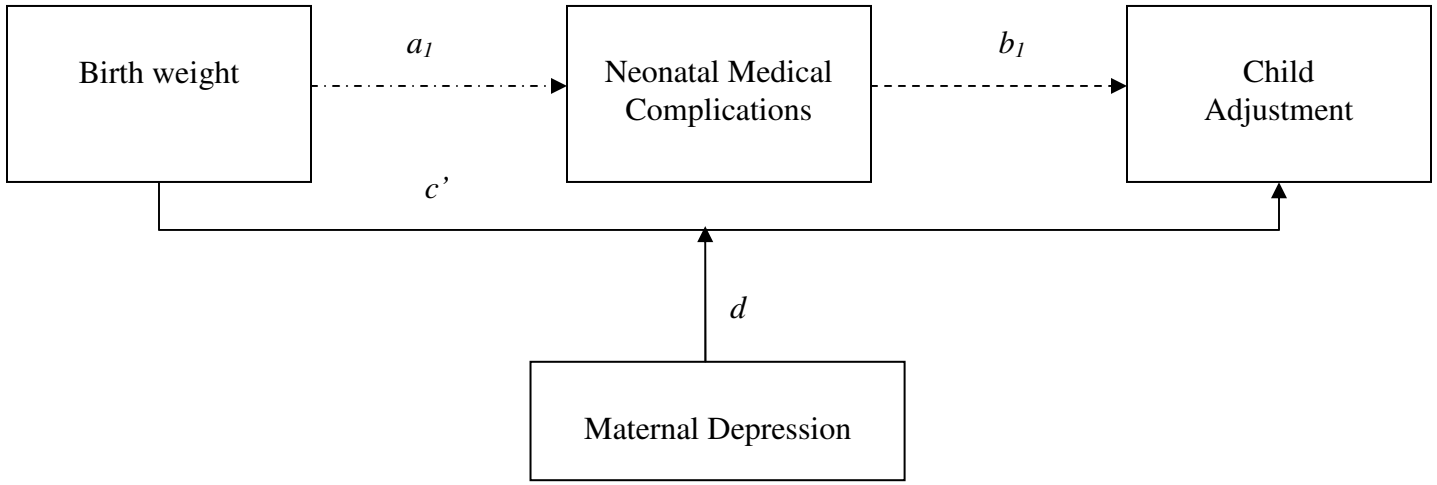
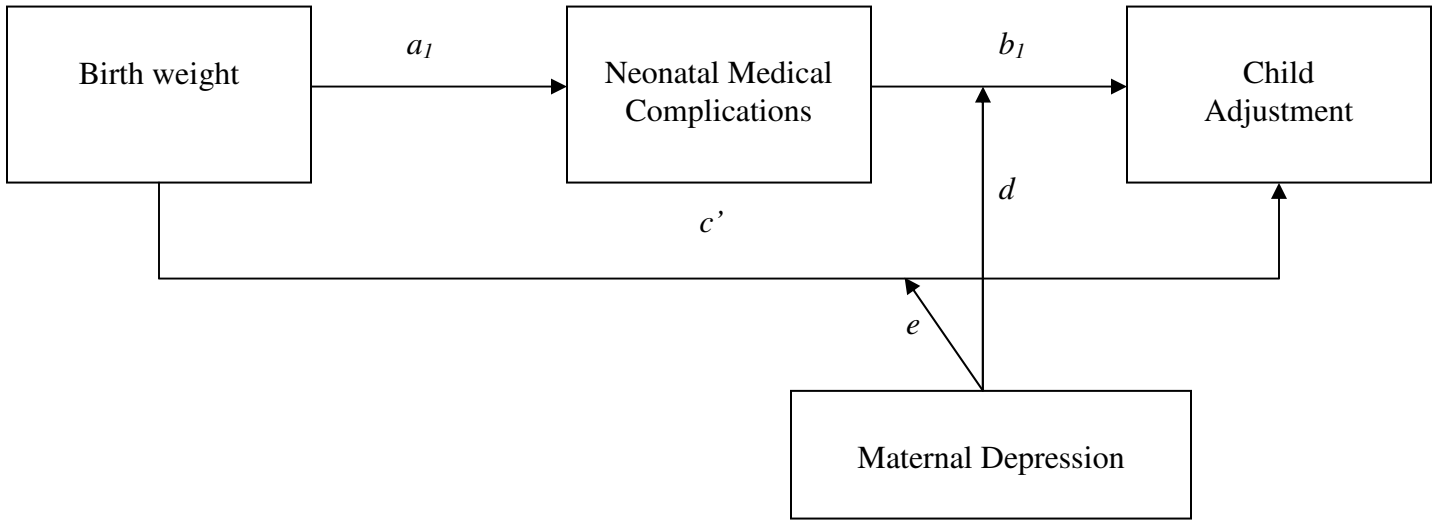

Birth weight
a_1
Neonatal Medical Complications
b_1
Child Adjustment
c'
d
Maternal Depression

Figure 6


Birth weight
a_1
Neonatal Medical Complications
b_1
Child Adjustment
d
c'
e
Maternal Depression

VITA

Natalie Williams was born on January 7, 1976, in Boston, MA. After attending public schools in Bloomington, Indiana, she received the following degrees: B.A. in History from Colgate University in Hamilton, NY (1998); M.A. in Clinical Psychology from the University of Missouri-Columbia (2003); and Ph.D. in Clinical Psychology from the University of Missouri-Columbia (2008). She currently is a Psychology Resident at the University of Mississippi Medical Center, located in Jackson, MS.