# Examining early childhood health and educational outcomes of late preterm infants in Manitoba: A population based study

by

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## Abstract

**Background:** Preterm birth continues to be an important public health concern. The late preterm population, born only 3 to 6 weeks premature, is not exempt from risk, as the last few weeks of gestation are important for both physical and cognitive development. Relatively few studies have examined outcomes for the late preterm population past the infancy period, nor have existing studies adequately adjusted for the role of socioeconomic status (SES). The purpose of this study was to assess whether late preterm birth was associated with poorer health, development and educational outcomes in the early childhood period, after controlling for SES.

**Methods:** A retrospective cohort study was conducted using administrative databases housed at the Manitoba Centre for Health Policy, including all children born late preterm (34-36 weeks gestation) and at term (39-41 weeks gestation) between 2000 and 2005 in urban Manitoba (N=28,100). Logistic regression was used to examine the effects of gestational age (GA) and SES on outcomes, after controlling for a number of child, maternal and family level covariates.

**Results:** Adjusted analyses demonstrated statistically significantly higher prevalence of lower respiratory tract infections (aOR=1.35, 95% CI [1.03-1.51]), asthma (aOR=1.18, 95% CI [1.04-1.33]), and ADHD (aOR=1.25, 95% CI [1.03-1.51]) among children born late preterm compared to term. Children born late preterm were more likely to be not ready in the language and cognitive (aOR=1.29, 95% CI [1.06-1.57]), communication and general knowledge (aOR=1.24, 95% CI [1.01-1.53]), and physical health and well-being (aOR=1.27, 95% CI [1.04-1.53]) domains of development at kindergarten. They were also more likely to repeat kindergarten or grade 1 (aOR=1.52, 95% CI [1.03-2.25]). The two groups did not differ in health care utilization at ages 4 and 7, in receipt of special education funding, in social maturity or emotional development at kindergarten, and in reading and numeracy assessments in the third grade. Child welfare involvement, low SES, receipt of income assistance, and young maternal age increased the odds of poor outcomes for both groups, particularly for the education outcomes.

**Conclusion:** Given that the late preterm population makes up 75% of the preterm population, their poorer outcomes have implications at the population level. This study underscores the importance of recognizing the developmental vulnerability of this population and of adequately adjusting for the social differences between children born late preterm and at term.

# Disclaimer

The author acknowledges the Manitoba Centre for Health Policy for use of data contained in the Population Health Research Data Repository under project #2014-017 (HIPC#2013/2014-48). The results and conclusions are those of the author and no official endorsement by the Manitoba Centre for Health Policy, Manitoba Health, Healthy Living & Seniors, or other data providers is intended or should be inferred. Data used in this study are from the Populations Health Research Data Repository housed at the Manitoba Centre for Health Policy, University of Manitoba, and were derived from data provided by Manitoba Health, Healthy Living & Seniors, Manitoba Education and Advanced Learning, Healthy Child Manitoba, Manitoba Jobs and the Economy, and Manitoba Family Services.

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# Chapter 1: Introduction

The incidence of preterm births continues to be an important public health concern globally. Despite progress in perinatal medicine, rates of preterm birth around the globe have been steadily increasing (World Health Organization [WHO], 2012). In developed countries like Canada and the United States, the persistence of preterm birth is seen as a significant and poorly understood public health concern that is influenced by a multitude of factors, having both social and economic implications (Heaman et al., 2005; Heaman et al., 2012; Heaman et al., 2013; WHO, 2012). According to the World Health Organization (2012), decreases in preterm births from the 1960s to the 1980s can be attributed in part to improvements in socioeconomic factors, antenatal care and technological advancements. Yet, despite ongoing community and clinical efforts to decrease the preterm birth rate in Canada, there was a steady increase in the preterm birth rate from 6.4% in 1981 to 8.4% in 2004, which has since leveled out (Public Health Agency of Canada [PHAC], 2008). This increase is thought to be due to increasing rates of obstetric intervention, for both medically and non-medically indicated reasons, older maternal age, and increases in multiple births (PHAC, 2008). In addition to these factors, the American College of Obstetricians and Gynecologists (ACOG) confirm that preterm birth rates have also increased due to a dramatic rise in late preterm births, defined as births between 34 and 36 weeks of gestation (ACOG, 2008).

With increases in survival of preterm infants, there also follows both short- and long-term consequences on the health and development of the infant. The impact of prematurity comes in two forms: the immediate health implications of early gestational age (GA) at birth, and; the long-term health, developmental and economic consequences for individuals, families and populations. Intervening prior to full maturity is thus a difficult choice, where it is necessary to balance early risks and benefits with potential future benefits and consequences (CIHI, 2004). Over the last decade, it has come under increasing attention that though born only 3 to 6 weeks early, those born late preterm are not exempt from risk.

There is an inverse relationship between adverse outcomes and GA, where earlier GA is associated with significantly greater risk of morbidity and death. As such, while it is well known that being born very premature (<28 weeks GA) has obvious health implications, more attention is now being paid to infants born late preterm (34-36 weeks GA), as they have been shown to have worse outcomes than those born at term and they represent a much larger proportion of births overall, making their outcomes non-negligible at the population level (Boyle, 2012; CIHI, 2009; Heaman et al., 2012; Kramer, 2009; Ruth, Roos, Hildes-Ripstein, & Brownell, 2012; Statistics Canada, 2009). However, despite extensive research on outcomes during the infancy stage, fewer studies have looked at the long-term outcomes in this population and none have focused specifically on the relationship between socioeconomic status (SES) and GA.

Findings of poorer outcomes in the infancy stage have led to the recognition that this population is not as low risk as previously thought and raised concerns among clinicians and academics regarding the strong potential for long-term morbidities, resulting in several recommendations for further follow-up (Baron et al., 2011; Morse et al., 2009; Moster, Lie & Markestad, 2008; Raju, 2006; Raju, Higgins, Stark, & Leveno, 2006). Furthermore, given the interplay between poverty, social disadvantage and poor obstetrical and child outcomes, examining preterm birth through a socioeconomic lens is warranted.

The early childhood period is known to be a critical point in development and an essential time to establish lifelong health and well-being. From a life course perspective (Fine & Kotelchuck, 2010), it is critical to view childhood as a pivotal time for reducing inequities and in providing health and social interventions at the appropriate time(s) to the appropriate population(s).

## 1.1 Preterm birth epidemiology and trends

**What is a "late preterm" birth?** Preterm birth refers to a birth that occurs before 37 weeks gestation, and is often classified into early preterm (<34 weeks) and late preterm (34-36 weeks) groupings (American College of Obstetrics and Gynecology [ACOG], 2013). Although infants born 37 weeks and later are considered term, the early term (37-38 weeks) group has also been differentiated from the late term group in recent years, as they have been found to incur greater risk of morbidity and mortality than those born at term (ACOG, 2013; Sengupta et al., 2013). Infants born at 39 to 41 weeks gestation are thus referred to as term. In reference to the late preterm group (formerly 'near term'), this label has been coined within the last decade so as not to under-emphasize risk and need for monitoring and follow-up within this population (Raju et al., 2006).

Late preterm infants may appear outwardly mature enough to be managed in a manner similar to that of term infants (Whyte, 2010); yet, despite their outwardly similar appearance, it has been noted that they are physiologically and metabolically immature (Engle et al., 2007). Similarly, this period is recognized as one when the risks are low enough to allow premature labour to continue or to intervene when continued pregnancy may endanger the health of the mother or fetus (Whyte, 2010). This immaturity includes major differences in brain composition, where brain weight at 34, 35 and 36 weeks is 67, 72 and 80% the weight of those born at term, respectively (Guihard-Costa & Larroche, 1992; Kinney, 2006). This immaturity also includes challenges with temperature stability, immune system development, and in apnea and lung development (Raju et al., 2006). Many late preterm infants are also discharged within 48 hours, and thus not surprisingly, have been found to have higher readmission rates that those born at term (Raju et al., 2006). Paradoxically, those born at 36 weeks have been shown to be at increased risk for readmission compared to early preterm infants, which may be explained by more frequent delayed discharge of infants at 34 and 35 weeks (Escobar, Clark, & Greene, 2006; Ruth, Hildes-Ripstein, & Brownell, 2014).

In Manitoba from 2005/06 to 2008/09, the preterm birth rate was 7.8%, of which approximately 76% of those (or 5.9% overall) were born at the late preterm stage (Heaman et al., 2012). Within Winnipeg, births at the late preterm stage were significantly higher in the lower SES areas of Downtown (8.0%) and Point Douglas (7.3%) compared to Winnipeg areas that are more socioeconomically advantaged (Heaman et al., 2012).

**Variation in preterm birth by SES in Manitoba.** Manitoba does not stand out relative to other provinces in preterm birth rates (7.8 per 100 live-births), sitting right at the Canadian average (CIHI, 2009). However, relative to other provinces, Manitoba reports the highest proportion of babies born in the lowest income quintile (31.2%) and is the only province to show a statistically significant disparity in preterm birth rates between the highest and lowest income neighborhoods (CIHI, 2009). Furthermore, preterm births are highest among babies born to first time mothers and mothers with high parity (3 or more babies), and Manitoba has the highest proportion of high parity births (13.8%) (CIHI, 2009). Although preterm birth occurs across all income quintiles, risk factors for preterm birth tend to be more prevalent in lower income groups or neighborhoods (Heaman et al., 2012), as mothers living in low-income neighborhoods tend to experience more social and economic disadvantages that can affect perinatal outcomes (Kramer et al., 2000). Given that the interplay of SES and birth outcomes in Manitoba is greater than in other provinces, examining the relationship between late preterm births and SES in this population is thus fitting.

In addition to the variation between provinces in preterm birth, there are also elevated rates among certain subpopulations. According to Heaman et al. (2005), Indigenous women in Manitoba have approximately a 17% higher incidence of preterm birth than non-Indigenous women (Heaman et al., 2005). Many of the risk factors for preterm birth, including low maternal age, low income, receipt of income assistance, previous preterm birth, low education, smoking and medical conditions, occur in combination, particularly among women of low socioeconomic status (SES), suggesting that the etiology of preterm birth is multifactorial and highly correlated to poverty (Behrman & Butler, 2007; Heaman et al., 2005; Heaman et al., 2012; Heaman et al., 2013; WHO, 2012).

Preterm birth rates also vary by geographic area. When comparing the relationship between area-level income quintile and preterm birth over two-time periods (1996/97-2000/01 and 2001/02-2005/06) a significant relationship was found between the two during the second time period only in urban Manitoba, with higher rates occurring in low-income areas (Brownell et al., 2008). Despite a higher prevalence of prematurity in lower SES groups, prematurity occurs in all income quintiles, ranging from 7.0% (income quintile 5) to 8.9% (income quintile 1) of live births in Winnipeg (Winnipeg Regional Health Authority [WRHA], 2012). When disaggregating these figures further by neighbourhood clusters, this variation increases from a low of 6.1% of births overall in Fort Garry (a neighbourhood with relatively high SES) to 11.5% of births overall in Point Douglas (the neighbourhood with the lowest SES) (WRHA, 2012). When dividing these into preterm birth categories, the proportion of preterm births considered to be late preterm is highest and significantly different from the overall Winnipeg rate (6.0%) in the neighbourhoods with the lowest SES: Downtown (8%) and Point Douglas (7.3%) (Heaman et al., 2012).

### 1.2 Scope of the problem

**Costs.** Total health care spending for maternal and infant care is substantial, accounting for approximately 1 in 10 dollars spent by hospitals on inpatient care, and significantly more for those with adverse outcomes (CIHI, 2006). In Manitoba, the treatment of very premature infants (<750g) is the top cost per case of all hospital expenditures (average weighted direct cost of $99,612), though these cases are relatively rare (Finlayson et al., 2009). In addition, average in-hospital costs are estimated to be approximately 9 times higher for singleton preterm births when compared to those born at term, (CIHI, 2009; Finlayson et al., 2009). Loftin et al. (2010) note that although costs are substantially lower at higher gestations, due to the higher number of late preterm births, this population contributes a considerable portion of the overall costs. It has been estimated that a delay in delivery from 34 to 35 weeks provides a 42% reduction in average neonatal costs, and delay from 35 to 36 weeks a further 38% cost decrease (Loftin et al., 2010). Although this cost reduction is not rationale to delay delivery when indicated, it is an important aspect to consider in association to the impact of prematurity at the late preterm stage when a large number of infants are affected.

In addition to the medical costs during the first year of life, and more importantly for the context of this study, are the potential long-term morbidities associated with the survival of premature infants, which incur significant family, medical, educational and societal costs over the lifetime. Using a previously developed burden of illness model from the United Kingdom (UK) and administrative population-based data from Quebec, Johnston et al. (2014) estimated the overall economic burden of prematurity in Canada using a Markov decision model. Although the estimated cost per child over the first 10 years of life was substantially lower among late preterm infants ($10,010) compared to those born extremely premature, when considering direct and indirect costs, national-level costs were greater for moderate ($255.6 M) and late preterm ($208.2 M) infants compared to those born at earlier GAs ($123.3 M), due to their larger population size (Johnston et al., 2014). Although the highest medical costs are incurred in the neonatal period and prior to age two, higher utilization and costs were found to extend into childhood (Johnston et al., 2014). The economic costs of technology, intensive care, and follow up services may be increasingly important given the concerns for health care sustainability and cost containment, especially when a large number of infants are affected.

### 1.3 Early Childhood Development in Manitoba

Manitoba's ongoing commitment to early childhood development emanates through the addition and expansion of maternal and early years programs since the September 2000 First Ministers Meeting Communique on Early Childhood Development and through the establishment of the Healthy Child Committee of Cabinet and the Healthy Child Manitoba Office, and the implementation of the Healthy Child Manitoba Act (Health Council of Canada, 2006). Through the ongoing efforts of key stakeholders as well as significant cash transfers from the federal government following the initiation of the Early Childhood Development Initiative, Manitoba has witnessed the development of a continuum of supports and strategies that contribute to achieving positive early childhood development and promoting population health, as outlined by one of the goals in the 10-Year Plan to Strengthen Health Care. Moreover, Manitoba is seen to be at the forefront of early childhood development initiatives for its collaboration with multiple sectors and levels of government (Health Council of Canada, 2006; Sanderson, 2014).

In a study conducted by the Manitoba Centre for Health Policy (MCHP) examining the health of Manitoba children from 2000-2010, researchers found that there have been positive gains among Manitoba children in hospital and physician use, high school completion, teen pregnancies and intentional injuries (Brownell et al., 2012). These gains in the health and well-being of children can likely be at least partly attributed to the ongoing investments by the provincial and federal governments to early childhood development over the past decade, suggesting that through the development of effective policies and programs, poor health among children is modifiable (Brownell et al., 2012; Health Council of Canada, 2006). In the case of preterm birth, understanding the interaction between prematurity, SES and their interrelated risk factors is crucial in determining strategies to increase child well-being and success early in life.

### 1.4 Gaps in preterm research

Increasingly, findings demonstrate that late preterm infants are not risk free, as the last few weeks of gestation are important for physical and mental development and disruption of this incurs both short and long-term disadvantages in early childhood development. Many infants have two interrelated classes of risk factors, social and biological, and understanding this relationship is important when developing strategies for reducing inequalities in health and educational outcomes. In particular, incorporating measures of SES, particularly income, is a new addition to the literature when studying the early childhood development of children born late preterm, and its inclusion has been based on the need to recognize the consistent associations between prematurity and poverty when approaching policy and clinical decision-making. Based on findings in the neonatal period, Ruth et al. (2012) noted that physicians and health care providers should be aware of programs available to assist the late preterm population and their families in seeking supports post-discharge. Similarly, if early and middle childhood disadvantage is evident in this population, these supports should be explored and extended accordingly.

According to Boyle (2012), given emerging findings, it is crucial to conduct more longitudinal studies that allow for follow up of late preterm infants from birth to childhood to: (1) allow for a greater understanding of the potential ongoing needs of these children as they age, (2) to identify groups that may be at higher risk, and (3) to highlight the prenatal, perinatal and neonatal factors that might influence later outcomes and be modifiable. Although beyond the scope of this study, results may also have clinical implications for clinicians who must weigh the risks and benefits of non-spontaneous early delivery, particularly in the United States where more deliveries for non-indicated reasons occur more frequently than in Canada. According to a study conducted by Gyamfi- Bannerman et al. (2011), 18.3% of the late preterm population was found to be delivered for non-evidence based reasons, thus having potentially avoidable preterm deliveries. Given the short-term morbidity associated with early delivery, and potentially longer-term effects, the need to reevaluate indications warranting preterm delivery has been stated (Gyamfi-Bannerman et al., 2011). Because the recognition of adverse outcomes in this population has been a relatively recent development in neonatology, new multidisciplinary guidelines for management have been released in attempts to improve outcomes, focusing particularly on the need for short and long term follow-up, not just in hospital care (National Perinatal Association, 2012). These guidelines reinforce the need for developmental, behavioral, growth, respiratory and sensory screening and the potential need for specialized supports and referrals (National Perinatal Association, 2012). They also include screening for several family risk factors, but do not include any consideration of SES. Although late preterm in-hospital protocols have been initiated in Manitoba in recent years, more research is needed to inform guidelines post-discharge (Winnipeg Regional Health Authority, 2010). As it stands in Manitoba, currently no additional supports are given to children born late preterm and they aren't routinely followed up over time.

This study highlights the difference between late preterm and term neonates beyond the first year of life, and also elucidates the underexplored role played by SES. Given the large population attributable risk associated with babies born late preterm, the findings have major implications for health and education services and serve to inform future programmatic decisions. In addition, unlike many other studies, it does not include the early term population in the term comparison group, which would underestimate the true risk in the late preterm population.

### 1.5 Research Questions

The purpose of this study was to assess whether GA at birth, specifically being born at the late preterm stage, is associated with health and development in the early childhood stage, before and after controlling for a variety of biological and social factors. To do this, a number of health and educational outcomes were assessed between the ages of 1 and 8 years, comparing those born late preterm to those born at term. Given increased morbidity and mortality among infants born late preterm during the first year of life and mixed findings afterwards, follow-up into the early childhood stage using a population-based sample is warranted.

The specific objectives of this study were:

1. To examine characteristics of the late preterm infant population at the child, maternal and family level in urban Manitoba, and how those differ to those born at term;

2. To compare health outcomes up to 8 years of age among former late preterm and term infants, including lower respiratory tract infections, asthma, attention deficit hyperactivity disorder (ADHD), and health services utilization at age 4 and 7;
3. To compare educational and developmental outcomes of former late preterm and term infants, as measured by school readiness using the Early Development Instrument (EDI), receipt of special education funding, grade repetition in kindergarten or grade 1 and grade 3 reading and numeracy assessments;
4. To examine the relative association of medical and social factors throughout the early childhood stage with health, educational and developmental outcomes, and how these are associated with prematurity.

## 1.6 Hypotheses

Prior to undertaking analyses, the research hypotheses were as follows:

1. Children born late preterm will have poorer childhood health, educational and developmental outcomes than children born at term.
2. There will be a linear relationship between GA, SES and outcomes, where higher GA group and income quintile will be associated with better outcomes.
3. Social factors will have a stronger association with outcomes than medical factors.

# Chapter 2: Literature Review

Preterm births can result in a range of short and long-term complications and morbidities that put those affected at a further disadvantage over the life course, especially for those of low SES (WHO, 2012). In the short term, these adverse outcomes include higher rates of morbidity and mortality, poor health outcomes (including respiratory distress, hypoglycemia, prolonged physiological jaundice, apnea, feeding difficulties, late neonatal sepsis and sudden infant death syndrome), frequent hospitalization during the first year of life and recurring respiratory infections (Bastek et al., 2008; Escobar, Clark, & Greene, 2006; Gilbert, Nesbitt, & Danielsen, 2003; Wang, Dorer, & Fleming, 2004; Ruth et al., 2012). Within the last decade, studies have begun to examine the health and development of this population, with poorer outcomes identified in several areas including neurodevelopmental issues (including developmental disabilities, visual/hearing impairments, cerebral palsy and poor central nervous system functioning) (McGowan, Alderdice, Holmes, & Johnston, 2011; Teune et al., 2011), learning disabilities (Nepomnyaschy et al., 2012), socio-emotional difficulties (Guedeney, Marchand, Martin, Cote, & Larroque, 2012) and poorer school performance (Lipkind, Slopen, Pfeiffer, & McVeigh, 2012; McGowan et al., 2011). These outcomes have potentially large social and economic implications, and findings to date will be explained in greater detail below.

The impact of prematurity at 34-36 weeks gestation has only recently received increasing attention, which has included changes to the definition and terminology, identification of knowledge gaps and research priorities, and changes to clinical care (Raju, Higgins, Stark, & Leveno, 2006). Despite well-established morbidity among late preterm infants, little was known on their long term development prior to 2005. Since that time, many of the existing studies considered late preterm as a subgroup of analysis and included early term (37-38 weeks gestation) as part of the term comparison, despite findings that suggest infants born early term are not the same as those born at term (Engle et al., 2007). With this in mind, a systematic review conducted by McGowan and colleagues in the United Kingdom in 2011 identified a total of 10 studies that truly examined the childhood development (1-7 years of age) of late preterm infants born at 34-36 weeks GA, finding poorer outcomes in relation to neurodevelopmental disabilities, educational ability, early intervention requirements, disabilities, and physical growth when compared to those born at term (39-41 weeks) (McGowan et al., 2011). Research in this area has since increased, particularly in the areas of asthma, neurodevelopmental outcomes, and academic achievement.

## 2.1 Review of research on early childhood outcomes of late preterm children

**Health Outcomes.** Several larger population-based studies have identified poorer general health among children born late preterm, including higher rates of morbidities at 32-64 months (Gyamfi, 2009), higher rates of cerebral palsy, developmental disabilities and mental retardation up to 5.5 years of age (Petrini et al., 2009), a number of social and medical disabilities up to 36 years (Moster et al., 2009), and measures of general ill health, hospital admission and longstanding illness at 3 and 5 years (Boyle et al., 2012). The population-based UK study by Boyle et al. (2012) found higher adjusted odds of asthma and wheezing at age 3 (aOR=1.3, 95% CI 1.0-1.5) and 5 (aOR=1.5, 95% CI 1.2-1.8) and for three or more hospital admissions between the ages of 9 months to 5 years (aOR=1.9, 95% CI 1.3-2.7) among late preterm (34-36 weeks) verses term (39-41 weeks) children. The late preterm group was also found to have the highest proportion of children classified as obese, to have significantly higher adjusted odds of having any longstanding illness at 3 and 5 years of age (aOR=1.2, 95% CI 1.0-1.5 and aOR=1.5, 95% CI 1.2-1.8), and any long standing illness which limited their child’s activities at 3 and 5 years of age (aOR=2.1, 95% CI 1.4-2.9 and aOR=1.7, 95% CI 1.3-2.3). Finally, Boyle et al. found prescribed asthma drugs to be significantly higher in the late preterm population at 5 years, compared to those born at term (aOR=2.2, 95% CI 1.6 to 3.1). When examining growth, a Brazilian study by Santos et al. (2009) found that late preterm children grow faster than children born at term, but are at increased risk of underweight, stunting and wasting at 12 and 24 months of age. Gyamfi (2009) found opposing results, reporting similar height and weight percentages, between 32 and 64 months, to term infants.

Several of the above noted studies identified a gradient in health by GA, where health outcomes improved with each successive increase in GA group (Boyle et al., 2012; Gyamfi, 2009; Moster et al, 2009). Boyle et al (2012) also found that although morbidity was higher in lower GA ranges at the individual level, the population attributable risk (PAR) was much larger for the late preterm population than those born before 32 weeks gestation for three or more hospital admissions at 9 months to 5 years (aOR=4.1, 95% CI 1.0 - 7.7 vs 3.8, 95% CI 1.3 - 6.5) and in having any long standing illness limiting activities at 3 (aOR=5.6, 95% CI 2.0 - 9.9 vs 3.2, 95% CI 1.2 - 5.6) and 5 years of age (aOR=3.6, 95% CI 1.2 - 6.5 vs 2.7, 95% CI 1.1 - 4.3).

***Asthma.*** Given that respiratory morbidity in the infancy stage has generally been established among the late preterm population, including such conditions as respiratory distress, RSV infection, and childhood wheezing (Pike & Lucas, 2014), several studies have also begun to examine the continuation of this morbidity into the early and middle childhood stages, with mixed results to date. The mechanisms behind poorer respiratory outcomes among children born preterm are mainly due to the interruption of normal intrauterine development and delivery of an infant at early stages of lung development (Colin, Mcevoy, & Castille, 2010). Delivery at 34-36 weeks GA occurs during the transition between the saccular and alveolar periods, which is among the most rapid periods of lung maturation (Langston, Kida, Reed, & Thurlbeck, 1984). Besides underdeveloped lung function at the time of delivery, there are also thought to be a number of factors in the pre and post-natal period that influence later lung function, or asthma specifically, and include such exposures as maternal smoking, stress and anxiety, infections, infertility treatment, fetal growth restriction, and risk factors such as prematurity, low birth weight, birth mode, and early life infections (Calogero & Sly, 2010) Despite an association between preterm birth and asthma, few studies have examined the development of asthma within the late preterm population.

To date, five studies have examined asthma or lung function among children born late preterm, two of which have just recently been published. Abe et al. (2010) were the first to examine this association, conducting a retrospective cohort study using data from the National Health and Nutrition Examination Survey to examine whether late preterm birth was a risk factor for physician diagnosis of asthma at 2- 83 months of age. This study estimated the probability of children not developing asthma by age in months using Kaplan-Meier Survival functions and used Cox Proportional Hazard regression to estimate hazard ratios and 95% CI for GA and asthma risk, adjusting for confounders. Although late preterm birth showed a modest crude association with asthma (cHR=1.5, 95% CI 1.0-2.3), multivariate analyses demonstrated late preterm birth to be weakly, but not statistically significantly, associated with physician diagnosis of asthma (aHR=1.3, 95% CI 0.8-2.0, p=0.30). The authors concluded that these findings reflect the need to identify subgroups within the late preterm population who may be at risk for long-term respiratory outcomes, for example, those who have additional risk factor such as maternal morbidity (Abe et al., 2010).

Goyal, Fiks and Lorch (2011) were next to examine the development of asthma in early childhood. In this study, preterm gestation was found to be significantly associated with increased diagnoses of persistent asthma (aOR=1.68, 95% CI: 1.01-2.80) and receipt of one or more inhaled corticosteroid prescription (aOR=1.66, 95% CI: 1.20-2.29) at 18 months, but not asthma diagnoses (aOR: 1.26 [95% CI: 0.92-1.73]), after adjusting for clinical and demographic covariates (gender, race, insurance, income below the federal poverty level, delivery method, breastfeeding, and atopy) (Goyal et al., 2011). Children born late preterm were also found to have a significant incident rate ratio for acute outpatient visits with wheeze compared to those born at term (aOR=1.44, 95% CI 1.24-1.67) (Goyal et al., 2011). These results are based on a retrospective cohort analysis of children seen at a primary care site for well-child care within the first 30 days of life and followed up to 18 months at 31 practices in Philadelphia, using multivariate logistic or Poisson models.

Lung function has also been examined at 8 to 9 and 14 to 17 years of age using data from the Avon Longitudinal Study of Parents and Children. However, GA groupings were divided into 25-32, 33-34, 35-36, and 37-43 week categories. Spirometry measures were found to be significantly lower in the 33-34 week group and comparable to those born at 25-32 weeks gestation, when compared to those born at term (37-43 weeks) (Kotecha et al., 2011). They continued to have reduced lung function at 14-17 years of age, but showed improvements in forced expiratory volume in 1 second ($FEV_1$) functioning. Reported rates of asthma at 7.6 years of age revealed asthma rates of greater than 20% in the 25-32 and 33-34 week gestation groups, and less than 15% in the 35-36 week group (Kotecha et al., 2011). By 13.8 years of age, rates of asthma were similar in all groups at 23-30% (Kotecha et al., 2011).

Harju et al. (2014) note that GA at birth is one of the most significant determinants of asthma, showing both a gradient effect with increasing prematurity and one where risks are stronger in early childhood and diminish later in life. In an observational hospital-based clinical birth database, they found that although risk was highest among the very preterm group (<32 weeks, aOR=3.9), risk of asthma was also significantly higher among those born late preterm and early term (aOR 1.7 and 1.2) after controlling for maternal asthma, diabetes, gestational diabetes, hypertension, chronic diseases at time of pregnancy, maternal age, parity, pre-pregnancy body mass, smoking during pregnancy, marital status, use of assisted reproductive technology (ART), child sex, age, 5-minute Apgar score, and mode of delivery (Harju et al., 2014). Although there was a significantly higher prevalence of asthma for children born very preterm compared to the general population, based on the larger number of infants born at late gestations, the burden of asthma in this study was associated mainly with deliveries in the late preterm and early term stages due to their larger population size (Harju et al., 2014).

Saifi and Bird (2015) note that the study by Harju et al (2014) was limited, as they did not control for environmental and social factors after birth that are potential risk factors for asthma development in children, nor did they consider asthma severity (Saifi & Bird, 2015), the latter of which is difficult to do with administrative databases. Additionally, Vogue and colleagues believe that the inconsistent findings in previous studies that have examined asthma in children born late preterm are due to unmeasured confounding (Vogue, Katusic, Qin, & Young, 2015). They attempted to overcome these limitations by applying propensity score matching to a population-based birth cohort born in Rochester, Minnesota, between January 1, 1976 and December 31, 1982 (n=7040). The propensity score was formulated using the following covariates: GA, sex, size for gestational age (SGA), race, twin gestation, paternal and maternal age at birth, single parent, maternal education, complication not related to pregnancy, birth induction, labor complication, maternal smoking during pregnancy, family history of atopic disease, and required hospitalization. Although there appeared to be a difference in asthma development between children born late preterm and term in the univariate analysis before matching on propensity scores, they found no significant difference in risk of asthma between these two groups at ages 5 to 7 after matching and controlling for confounders (HR: 1.13 [95% CI 0.95-1.70], p=0.56).

To summarize, examining the research to date in this area yields inconsistent findings. Several studies examined asthma diagnosis within the first few years of life (Abe et al., 2010; Goyal et al., 2011), a condition that is difficult to accurately detect prior to age 5 (Fontes et al., 2005). Furthermore, given that a number of factors influence the development of asthma, adjusting for necessary confounders is necessary to adequately examine the potential association between late preterm birth and asthma diagnoses. Though there is a well-established association between low SES and poor health, few studies have assessed the role of SES on asthma development in the late preterm population. A recent population-based retrospective cohort study conducted in Finland found no evidence of a direct association between maternal SES and childhood asthma in a hospital-based cohort of singleton children born at any GA (Harju, Keski-Nisula, Georgiadis, Raatikainen, Raisanen, & Heinonen, 2015). Instead, this association was thought to be indirect and a result of differential behavior and health care use among low social class women during pregnancy (Harju, Keski-Nisula, Georgiadis, Raatikainen, Raisanen, & Heinonen, 2015). The extent to which both GA and SES influence asthma development has yet to receive attention in the literature.

**Educational and developmental outcomes.** Given that the last few weeks of prenatal development are critical periods for brain development, the potential for mild cognitive, behavioral and academic impairments among children born late preterm has been suggested. A recent review of the literature in this area confirmed the developmental vulnerability of the late preterm population, though the majority of studies have focused on those born extremely premature. Because deficits among the late preterm population are not always severe, school age has been thought of as a time when many developmental setbacks may be detected (Moreira, Magalhaes, & Alves, 2013). From their review, Moreira and colleagues concluded that in considering evidence from the past decade, children born late preterm are more susceptible to poorer motor development, behavior, and school abnormalities when compared to term infants, and that the severity of these abnormalities is determined by both biological and environmental factors (Moreira et al., 2013). They also note the need to expand and properly assess the development across all GA groups, as preliminary results suggest that those born moderate to late preterm are also susceptible to developmental deficits and comprise a much larger number of births overall (Moreira et al., 2013).

In the literature, developmental outcomes have been studied a number of ways, including development in the preschool years, educational outcomes, including academic achievement, cognitive functioning, learning disabilities and need for special education funding, school readiness and development, and diagnoses of ADHD.

***Development in the preschool years.*** To examine how the late preterm population does in the preschool years, Nepomnyaschy et al. (2012) compared healthy late preterm (34-36 week) and at term (37-41 weeks) children on 18 cognitive, motor, and behavioral outcomes at 2 and 4 years of age (Nepomnyaschy, Hegyi, Ostfeld, & Reichman, 2012). Though unadjusted models revealed significantly lower scores for children born late preterm on all cognitive assessments, after adjusting for a comprehensive list of variables, only scores relating to language use were significantly lower at 2 years. At 4 years, children born late preterm continued to score significantly lower on language, as well as in reading, vocabulary, and math ability, after adjustment. Their findings suggest that late preterm birth is associated with small but significant set-backs at 2 and 4 years of age, but with generally stronger associations at age 4. They suggest that subtle differences at age 2 call for early testing and intervention to ameliorate the development of late preterm children before deficits escalate (Nepomnyaschy et al., 2012).

Others sought to examine whether neurodevelopmental setbacks could be examined at age 2, early enough to alleviate poorer neurodevelopmental and academic performance in the future (Woythaler, McCormick, & Smith, 2011). With use of the Early Childhood Longitudinal Study – Birth Cohort, which has an over sampling of racial/ethnic groups in the US., researchers examined outcomes gathered using the mental development index (MDI) and the psychomotor development index (PDI). After adjusting for confounders (GA, plurality, maternal race, depression, prenatal care, primary language, infant gender, poverty level, delivery type, fetal growth, and any breastfeeding), children born late preterm were found to have significantly higher odds of severe developmental delay (aOR=1.51 [1.26 – 1.82]), milder developmental delay (aOR=1.43 [1.22 – 1.67]), severe psychomotor developmental delay (aOR=1.56 [1.29 – 1.88]), and milder psychomotor developmental delay (aOR=1.58 [1.37 – 1.83]) at 2 years of age. Findings demonstrated that social factors had the largest relative contribution to MDI measures, contributing approximately 46%, whereas medical factors contributed most to the PDI index, accounting for 59%. In particular, language spoken at home was the largest social contributor to the MDI, sex was the largest demographic contributor to significant mental delay, and being a child born late preterm was amongst the largest contributors to the PDI. Similarly, a prospective population-based study suggests that adverse effects are evident at age 2 among children born late preterm for neurodevelopmental disability, particularly in relation to cognitive deficits and language (Johnson et al., 2015). Based on these findings, it has been suggested that this population merits closer developmental follow-up in the pre-school period, given the effectiveness of early educational intervention and the potential to detect deficits early on and ameliorate later school outcomes (Woythaler et al., 2011).

***Educational outcomes.*** The first study to examine academic achievement among children born late preterm was conducted in 2008 using the Early Childhood Longitudinal Study Kindergarten Cohort (ECLS-K) data in the US, with direct child assessment test scores, teacher academic rating scales, and the presence of individualized education programs (IEP)/special education (Chyi, Lee, Hintz, Gould, & Sutcliffe, 2008). Evaluations were done in kindergarten, first grade, third grade, and fifth grade, and compared between children born moderately preterm (32-33 weeks GA), late preterm (34-36 weeks GA), and full term (37 weeks GA or higher). After adjusting for sex, race, and maternal education level, children who were late preterm had 24% higher odds for below average reading in the first grade, 22% higher odds for below math T-score in the first grade (but non-significant in other years), poorer math academic rating scores in kindergarten (aOR=1.25, 95% CI 1.05 – 1.49), greater odds of having an individualized education program (IEP) in kindergarten (aOR=1.38, 95% CI 1.00 – 1.89) and the first grade (aOR=1.44, 95% CI 1.08 – 1.91), and higher rates of special education in kindergarten (aOR=2.13, 95% CI 1.56 – 2.90) and the first grade (aOR=1.44, 95% CI 1.04 – 1.98) compared to those born at term. Although children who were born late preterm appear to catch up by later grades, as seen with non-significant findings in the above noted categories in grades 3 and 5, they were found to have poorer academic rating scale scores through to the fifth grade (aOR= 1.31, 95% CI 1.05 – 1.65) (Chyi et al., 2008).

At age 5, a population-based cohort of children born late preterm in England were found to have significantly higher risks of not reaching overall achievement compared to those born at term (39-41 weeks) in a number of areas, including (1) communication, language and reading (aRR=1.11, 95% CI 1.02-1.22), (2) mathematical development (aRR=1.16, 95% CI 1.00-1.34), (3) knowledge and understanding of the world scale (aRR=1.30, 95% CI 1.08 – 1.56), and (4) creative development (aRR=1.22, 95%CI 1.02-1.46), based on teacher assessments. No differences were found in physical, or personal, social and emotional development (Quigley et al., 2012). Models were adjusted for sex, ethnicity, birth order, multiple births, breastfeeding duration, month of birth, mother's age, marital status, maternal education, social class, and language spoken in the home, and though several factors were more important determinants of poor outcomes than prematurity, GA was still an associated risk factor (Quigley et al., 2012).

Williams et al. (2013) further contributed to the growing body of literature that suggests poorer neurocognitive development and academic achievement among those born late preterm. After controlling for maternal age at birth, maternal education, race ethnicity, gender, and year of birth, children who were born late preterm were found to have greater odds of failure for math (OR=1.17, 95% CI 1.13 – 1.22), reading (OR=1.13, 95% CI 1.08 – 1.18), and English Language Arts (ELA) (OR=1.15, 95% CI 1.11- 1.20) in the first grade, compared to those born at term (39-41 weeks).

In the third grade, Lipkind et al. (2012) found a linear association between GA and test scores through to 39 weeks of gestation. After adjusting for sex, maternal age, maternal race/ethnicity, insurance status, parity, low Apgar score, medical risk factors, complication of labor and delivery, NICU admission, days absent in the 3$^{rd}$ grade, and SGA, children born late preterm between 1994-1998 in New York City were found to have 30% higher odds of needing special education (aOR=1.34, 95% CI 1.29 – 1.40), 6.7% of a SD lower adjusted math scores, and 4.0% SD lower adjusted English language arts (ELA) scores on third grade standardized tests compared to those born at term (p<.0001) (Lipkind et al., 2012).

Similarly, Odd, Evans, & Edmond (2013) found that children born late preterm did poorer in standardized testing in primary school and had higher rates of specialized funding, but that age correction and year of education explained some of the school failure seen in those born extremely preterm, but also among those born at 32 to 36 weeks.

Most recently, Ahlsson et al. (2015) conducted a Swedish Register based study of school performance among 1,643,958 children born 1974 – 1991, examining school grades in the last year of compulsory schooling or at age 16. Using linear regression for continuous variables and probit regression for binary outcomes, the authors performed the analysis in 4 steps: (1) crude analysis (school grades + GA + maternal age), (2) crude plus added information on maternal and paternal education, (3) restricted the analysis to families with more than one child and compared siblings, including a variable for birth order, and (4) continued sibling analysis but restricted to pairs in which at least 1 had a GA of 40 weeks. The results of the analysis found a negative association of school performance with preterm birth after 31 weeks in both steps 1 and 2, which then vanished when preterm children were compared with their siblings in steps 3 and 4, suggesting that for birth after 31 weeks, it is the factors leading to preterm birth, rather than preterm birth itself, that has a negative impact on school performance (Ahlsson et al., 2015). They suggest that findings in other studies are thus attributable to other exposures (ie. sociodemographic), rather than GA (Ahlsson et al., 2015), at least later on in life.

***School readiness and development.*** In addition to standardized testing and performance in specific grades, others have examined school readiness and development in specific domains. When examining the impact of low birth weight, preterm delivery and SGA on cognitive and behavioral school readiness in a nationally representative sample in Australia, Chen et al. (2014) found that moderately preterm infants (32 – 36 weeks GA) performed 0.16 SD ($p<.01$) lower than term infants on the “Who am I?” assessment, which examines non-verbal language in the kindergarten year. Although this did not differ by family SES, preschool attendance among disadvantaged preterm children was found to lessen the risk of not being ready to begin school, though they were found not to catch up fully to their more advantaged peers by simply attending preschool (Chen et al., 2014).

During the pre-kindergarten and kindergarten periods, Morse et al., (2009) examined seven school aged outcomes among 7,152 healthy late preterm and 152,661 term children in the United States, excluding those with major CAs, multiple births, transfers to another hospital at birth, and those with a length of stay greater than 3 days at birth. Poisson regression models were fitted and adjusted for a number of control variables (mother’s age, race, maternal education, marital status, tobacco and alcohol use during pregnancy, participation in Medicaid during pregnancy, adverse pregnancy experience, Kotelchuck index of adequacy of PNC, pregnancy complications, labor and delivery complications, cesarean section, mechanical ventilation, and infant gender). The results demonstrated statistically significant differences in six of seven outcomes between the groups, including higher risks among the late preterm of developmental disability (aRR=1.19, 95% CI 1.29 – 1.43), suspension in kindergarten (aRR=1.19, 95% CI 1.10 – 1.29), disability in pre-kindergarten (aRR=1.10, 95% CI 1.05 – 1.14) and kindergarten (aRR=1.13, 95% CI 1.08 – 1.19), retention in kindergarten (aRR=1.11, 95% CI 1.07 – 1.15), exceptional student education (aRR=1.10, 95% CI 1.07 – 1.13), and being not ready to start school (aRR=1.04, 95% CI 1.00 – 1.09) (Morse et al., 2009). Their study, like others, also found each additional week in utero to be important, with those at 34 weeks GA more likely to be not ready to start school, and similar risk between the 35 and 36 weeks GA groups (Morse et al., 2009). Furthermore, although the absolute risks for poor outcomes in this population were low, the cumulative effects at the population level became more substantial (Morse et al., 2009).

On a similar note, data from the longitudinal preterm outcome project in the Netherlands assessed the separate and joint effects of moderate prematurity (32 to 36 weeks gestation) and low SES on developmental delay in early childhood (n=1470). The results of this study demonstrated that moderate prematurity and low SES are separate risk factors that have multiplicative effects on developmental delay in early childhood, in all domains but communication (Potijk, Kerstjens, Reijneveld, & de Winter, 2013).

Poulsen et al. (2013) examined the relation of GA across the spectrum to cognitive ability using the UK Millenium Cohort Study. Although children born preterm were more likely to be socioeconomically disadvantaged, adjusting for these factors reduced, but did not eliminate all effects. The late preterm group was found to score less than -1 SD below the mean on four of eight tests, after adjusting for confounding. At age 3, the Bracken School Readiness Assessment revealed a 30% greater risk of being assessed as not ready (aRR=1.30 [1.1 – 1.50]). At age 5, the risk for poorer spatial abilities and non-verbal reasoning were also elevated 1.4 (1.1 – 1.6) and 1.2 (1.0-1.5) times, based on the British Ability Scale II. At age 7, the adjusted risk for poor verbal reasoning was found to be 40% higher (aRR=1.40 (1.2 – 1.6) (Poulsen et al., 2013).

Similarly, using the Ages and Stages Questionnaire, children born at 34 and 35 weeks were found to have significantly poorer fine motor (OR=2.2, p=0.047) and personal-social functioning at 43-48 months, after adjusting for maternal and paternal education (Kerstjens et al., 2011).

Finally, a two-centre retrospective 1:1 matched cohort study examining children at 6 years of age found that being born late preterm was associated with behavioral problems and lower IQ at 6 and 7 years of age, independent of maternal IQ, residential setting and socio-demographics (Talge et al., 2010).

***Attention Deficit Hyperactivity Disorder (ADHD).*** Despite the fact that higher rates of ADHD have been diagnosed among preterm infants and that prematurity has been identified as a major contributor to the etiology of ADHD (Rowland, Lesene, & Abramowitz, 2002), few studies have examined the association between ADHD and birth at the late preterm stage. In 2006, Linnet and colleagues studied the association between prematurity and clinically verified hyperkinetic disorder (HKD) between 2 and 18 years of age, using a nested case-control study based on data from four Danish longitudinal registries. In this study, children born late preterm were found to have a 70% increased risk of HKD (aRR=1.7, 95% CI 1.2 – 2.5), after adjusting for socioeconomic factors, parental age, and familial psychopathology.

Conversely, Rogers, Lenze and Luby (2013) found no difference in ADHD rates during the preschool period, after adjusting for gender, ethnicity, family income, and IQ, but found increased odds of having any anxiety disorder (aOR=3.85, 95% CI 1.52 – 9.52), generalized anxiety disorder (aOR=3.50, 95% CI 1.03 – 11.94), and separation anxiety disorder (aOR=3.04, 95% CI 1.21 – 7.63). They also examined the impact of maternal depressive disorders (MDD) on the relationship between late preterm birth and preschool anxiety disorders, finding that maternal MDD fully mediated the relationship between GA and preschool anxiety, when comparing late preterm (34-36 weeks) and term (40-41 weeks) groups (Rogers et al., 2013).

Harris et al. (2013) also found no difference in neurodevelopmental outcomes when comparing children born late preterm (34-36 weeks) who had no significant morbidity, to those born at term (37-41 weeks). Using a population-based birth cohort, Kaplan-Meir methods were used to estimate the cumulative incidence of each outcome, and Cox proportional hazard models were used to fit and evaluate the association between GA category and each outcome, both unadjusted and adjusted for maternal education and the presence of perinatal complications. As noted above, adjusted hazard ratios revealed no significant differences in ADHD (aHR=1.05, 95% CI 0.64-1.73), learning disabilities in reading (aHR=1.11, 95% CI 0.77-1.59), writing (aHR=0.84, 95% CI 0.58 – 1.22), and math (aHR=1.03, 95% CI 0.73 – 1.45) between the two groups.

Even if the existing literature suggests no difference between late preterm and term groups in the risk for ADHD, it has been suggested that among children with ADHD, those born late preterm have lower attention scores than those born at term, as measured by the Continuous Performance Test, and also have lower relative concentrations of glutamate in the prefrontal region (Amor, Chantal, & Bairam, 2012). Although not among children born late preterm, a review of clinical cohort studies that examined the prevalence, etiology and risk factors for psychiatric disorders in extreme preterm infants found that the clinical presentation of ADHD is different among preterm children than those born at term (Johnson & Marlow, 2001). For example, there was a lack of male predominance, a lack of comorbid conduct disorders, a weaker association of ADHD with sociodemographic and family risk factors, and greater risk for symptoms of inattention rather than hyperactivity/impulsivity among children born late preterm compared to those born at term (Johnson & Marlow, 2011).

***Contrary findings.*** Despite overwhelming evidence that suggests poorer developmental outcomes among former late preterm infants, several studies have found no association after adjusting for potential confounders (Baron et al., 2009; Brown, Speechley, Macnab, Natale, & Campbell, 2014; Gurka et al., 2010; Harris et al., 2013). Among the first to examine the development of late preterm children in Canada, Brown and colleagues (Brown, Speechley, Macnab, Natale, & Campbell, 2014) found that in the context of social processes, children born late preterm were not significantly different than those born at term in their risk for developmental delay at 2 to 3 years of age (aRR=1.13, 95% CI 0.90-1.42) or receptive vocabulary delay at ages 4 to 5 (aRR=1.06, 95% CI 0.79-1.43). This was based on secondary analysis of the National Longitudinal Survey of Children and Youth, estimating adjusted relative risks using multivariable modified Poisson regression and block-wise entries of variables, including perinatal variables, GA, family structure, family functioning, proximal social processes, and other covariates.

In comparing outcomes during the preschool years, a single-centre retrospective cohort study conducted in the United States found that complicated (admitted to NICU) late preterm infants had significantly poorer general cognitive ability (GCA), nonverbal reasoning and spatial scores, with male gender as an additive risk factor for nonverbal deficit and GCA in the childhood period, while late preterm children who were not admitted to the NICU at birth did not differ from term (Baron et al., 2011).

Findings from a population-based birth cohort study (n=5699) conducted in Rochester, Minnesota also suggest that the risk for poor neurodevelopmental outcomes do not differ between healthy late preterm and term children when followed through to school completion or age 19 (Harris et al., 2013). Kaplan-Meir was used to estimate the cumulative incidence of each outcome and Cox proportional hazard models were fit to evaluate the association between GA category and each outcome, adjusting for maternal education and the presence of perinatal complications. Results from the adjusted models suggest no significant differences between late preterm and term children in the cumulative incidence of ADHD diagnoses (aHR: 1.05, 95% CI 0.64 – 1.73, p=0.84), learning disabilities in reading (aHR: 1.11, 95% CI 0.77 – 1.59, p=0.57), writing (aHR: 0.84, 95% CI 0.58 – 1.22, p=0.36), and math (aHR: 1.03, 95% CI 0.73 – 1.45, p=0.89). However, this study was conducted amongst white middle class communities, and thus may not be applicable to populations who are more diverse or of lower SES.

Finally, Gurka et al. (2010) used data from the National Institute of Child Health and Youth Development study of Early Child Care and Youth Development to compare healthy late preterm (34-36 weeks) to term (37-41 weeks) children on cognitive, achievement, socioemotional, and behavioral outcomes from age 4 to 15. This study found that among healthy children born late preterm, there were no differences between the two groups. However, this was among a socioeconomically advantaged population and consisted of a small sample size (n=1348 overall; n=53 <37 weeks), therefore, the results may not be generalizable.

***The influence of SES.*** Several studies note that SES has a greater impact on poor developmental outcomes than does GA, but that their effects are multiplicative, that is - both increasing the independent effect of the other (Potijk et al., 2013; Quigley et al., 2012). Others have found the effects of late preterm and early term births, though significant, to be small in comparison to other risk factors, such as sex, being born later in the year, and low maternal academic attainment (Quigley et al., 2012). These findings draw attention to the fact that many children born preterm and who have a low family SES are at a double jeopardy for poor development (Potijk et al., 2013), and that social factors, including SES need to be considered when examining developmental outcomes. Reichman, Teiler, & Moullin (2015) note that existing studies in this area have not been able to adequately control for sociodemographic factors, and thus, some of the effects of late preterm birth may be due to unobserved confounding factors.

## 2.3 Theoretical Framework

This study was guided by life course theory, a theoretical framework frequently used to guide maternal child health research (Fine & Kotelchuck, 2010). A life course model has been described by Ben-Shlomo and Kuh (2002) as one which is effective due to its ability to test not only the influence of early life course exposure with later outcomes, but also for its ability to examine possible pathways and confounding factors that mediate the outcome(s), an important consideration when examining the differential effect of early life exposures on outcomes. This theoretical framework is appropriate both for its population focus and attention to the social determinants of health and health equity. Furthermore, its focus on the impact of early events on later outcomes and consideration of the structural, social and cultural contexts in which these outcomes occur is particularly fitting and will help to interpret and conceptualize the results (Fine & Kotelchuck, 2010).

Life course theory focuses on several key concepts, including: cumulative impacts, early programming, critical or sensitive periods, risk and protective factors, and pathways or trajectories(Boivin et al., 2012; Fine & Kotelchuck, 2010). Cumulative impacts refer to the multiplicative effect of multiple stressors on health and wellbeing (Evans, Li, & Whipple, 2013; Fine & Kotelchuck, 2010). These can have direct impacts, but can also indirectly impact development by influencing behavior change and health seeking behaviors (Fine & Kotelchuck, 2010). Early programming is specifically important for this study and considers the impact of early life effects, including in utero exposure and maternal health before and during pregnancy, on infant and early childhood health and development. The notion of critical or sensitive periods recognizes that while all adverse exposures can negatively impact health and development, there are certain periods throughout the life course where their impact is the greatest (Fine & Kotelchuck, 2010; Kuh, Ben-Shlomo, Lynch, Hallqvist, & Power, 2003; Mishra, Cooper, & Kuh, 2010). Risk and protective factors then serve to either improve or diminish health across the lifespan, and include not only behavioral and biological risk, but also factors at the family, neighbourhood, community, social, and political levels (Fine & Kotelchuck, 2010). Finally, all of these concepts work along a pathway or trajectory where exposures do not occur in steps, but rather integrate and accumulate over time (Alwin, 2012; Fine & Kotelchuck, 2010). These key concepts are then used to (1) explain why health disparities exist across population groups, and (2) to understand which factors influence the ability of populations to reach their full potential, whether in a health or educational sense (Fine & Kotelchuck, 2010).

Hertzman (2012) notes that early life adversities do not occur randomly across populations, but rather occur unequally within lower socioeconomic groups, influenced by biological, psychological and social factors. Similarly, Ben-Shlomo and Kuh (2002) express how outcomes differ across place, time and differentially affect subgroups. These outcomes are thought to be explained by such concepts as timeline (cumulative impact of risk and protective factors), timing (during critical and sensitive periods), environment (with the influence of physical, social and economic environments) and equity (while considering the impact of broader socioeconomic impacts over time) (Fine & Kotelchuck, 2010).

Using the repository at MCHP to link multiple records to test early life exposures and outcomes over time corresponds well to life course theory. This methodological approach considers how trajectories are shaped not only by biological and early life physical circumstances, but also by social influences and their additive impact over time.

## 2.4 Factors that influence early childhood development – biological and social factors

Preterm children are unique in that they have a history of biological vulnerability, and in many cases, may be exposed to multiple additional risk factors, which make their environment vital for positive or negative effects on their development (Moreira, Magalhaes, & Alves, 2013). The mechanisms underlying the association between parental SES and pregnancy outcomes are not well understood. Several studies have described confounding variables as acting indirectly on the pathway from parental socioeconomic position (SEP) to birth outcomes (Rothman, Greenland, & Lash, 2008). Others have used sibling and twin designs to examine this association (Krieger, Chen, Coull, & Selby, 2005; Lawlor, Mortensen, & Nybo Andersen, 2011; Madsen, Andersen, Christensen, Andersen, & Osler, 2010). Lawlor et al. (2011) used sibling studies to show that increased risk of low birth weight and preterm birth among young mothers is explained by the early life consequences of the mother rather than the biological consequences of young maternal age. When examining the association between parental SEP, preterm birth and SGA using a cohort, sibling control, and case-crossover design, an association was found only between maternal education and SGA when comparing mothers who were siblings (Mortensen, 2013). The findings of this study suggested that the association between education and preterm birth is explained by factors shared by mothers who are siblings, and that early life course social and biological circumstances are important in understanding the educational or socioeconomic gradient in preterm birth and SGA (Mortensen, 2013).

The relationships between social class, perinatal complications and cognitive development are complex and interrelated (Alyward, 1992). Because of this, many children are born at a double disadvantage, particularly so in preterm infants, where poor biological and environmental factors often occur synergistically and build off of each other (Alyward, 1992). Findings from several studies have found demographic and economic factors, not obstetrical risk factors, to be greater determinants of the association between preterm birth and later cognitive functioning (Bee et al., 1982; Cohen et al., 1986; Sameroff & Chandler, 1975). Among the late preterm population, even by 2 and 4 years of age, demographic and economic factors were found to better explain the association between cognitive development and preterm birth (Nepomnyaschy et al., 2012). Similarly, a summary of the literature examining the relationship between biological and environmental risk suggests that though the two risk categories are synergistic, mild to moderate biological risk factors appear to be important in infancy, whereas environmental effects become more influential from late infancy to early childhood, and more stable environmental factors, such as SES, become more influential in early childhood (Alyward, 1992). Woolfenden et al. (2013) also note that even for those with a clear biological cause, there are still inequities in health outcomes due to social disadvantage. When exploring the effects of prematurity in the UCLA Longitudinal Project Cohort, findings indicated that the effects of biological risk were evident early on, but that this declined by 2 years of age (Signman, Cohen, & Forsythe, 1981). This study demonstrated that as children age, the environmental path seems to be most critical in determining outcomes, but that biological risk factors have indirect effects (Signman et al., 1981). Similarly, the Kanai Longitudinal Project found that at age 20 months, children from middle class homes who experienced severe perinatal complications had comparable intelligence to those with no biological risk living in low-income households (Aylward et al., 1982; Werner et al., 1967).

In line with life course theory, there is no single factor that can be identified as responsible for poor outcomes, but rather it is the accumulation, timing and continuity of risk that best determines outcomes (Alyward, 1992). Social and biological risks are thus difficult to separate out, as neither occurs in isolation, especially for children living in poverty. However, in general, the literature seems to suggest that social risks become the most important determinants for development as children age, and that the presence of both social and biological risk act synergistically on childhood development.

## 2.5 Mechanisms: preterm birth and poor outcomes

The mechanisms underlying the association of decreasing GA and poorer school performance are also multifactorial. The brain is still increasing in size at 34 to 36 weeks, weighing only 65 to 80% of the full term brain (Kinney, 2006; Kugelman & Colin, 2013). Thus, disruption of this growth in utero may play a part. Physiological immaturity is also thought to be another explanatory mechanism for poor brain development, due to the effects of temperature and blood sugar instability (Kapellou et al., 2006). The role of behavior and attention in school performance has also been postulated, given that late preterm children have been shown to have higher rates of ADHD (Lindstrom, Lindblad, & Hjern, 2011) and problematic behaviors (Talge et al., 2010).

Though research suggests a greater risk of poor outcomes among children born late preterm, it is difficult to tease out whether these risks are due to preterm birth, to the factors leading to preterm birth, or to the social environment where these children live and grow (Chan & Quigley, 2014). As noted by Raju (2013), the duration of gestation is only one of many factors affecting development, and thus, the degree of maturation can vary even at similar gestations. Based on existing literature, the extent to which biological and social variables influence outcomes varies not only on the outcome examined, but also by the individual, and the two are not mutually exclusive. Nonetheless, these risks should be considered in decision making of deliveries prior to full-term.

## 2.6 The importance of early investment

A wealth of research confirms that investing in children early, especially in those most disadvantaged, not only promotes economic efficiency and improves the productivity of the economy, but also decreases lifetime inequality and future strains on the health and education systems (Heckman, 2006; Heckman, 2008; Kershaw et al., 2011). Although the key to future health and well-being is largely influenced by positive early childhood development, many children have a suboptimal start and are developmentally vulnerable (Woolfenden et al., 2013). Scientific research on the young brain supports that a child’s brain becomes significantly less malleable over time, with the earliest years being the most essential and rewarding in terms of capital investment (Heckman, 2006). Further to this, Santos reaffirms that the learning gap already present in kindergarten is difficult to overcome and that early differences tend to persist onwards (Government of Manitoba, 2013; Heckman, 2006; Santos, 2009). Although later improvement of early disadvantage is possible, it is much more costly and difficult to achieve the same results later in life (Heckman, 2006; Heckman, 2008; Popli, Gladwell, & Tsuchiya, 2012). Evidence from numerous disciplines has concluded that there are periods in an individual’s development that are particularly influential in determining later development, and early childhood is viewed as a crucial stage in the trajectory of development (Popli et al., 2012). Heckman (2008) and others thus stress the importance of directing social policy towards the early years.

When considering the economic costs of early vulnerability in Canada, Kershaw and colleagues express that not enough attention is given to the level of developmental vulnerability faced by many children entering the school system (Kershaw et al., 2010). Approximately 1 in 4 children in Manitoba are deemed not ready for school learning in at least one domain of development, and struggle with basic competencies (Santos, 2009; Kershaw et al., 2010). Although data were not reported for children born preterm, among those born at a very low or low birth weight, the percentage of children not ready increased dramatically to 51% and 34.5% respectively (Santos et al., 2012; Sanderson, 2014). Similarly, poor health at birth is also linked to poorer outcomes at age 5, including illness and language and cognitive ability (Santos et al., 2012). Further to this, a strong correlation has been found between kindergarten vulnerability and poor outcomes in grade 3 (Brownell et al., 2012). When modeling variations in grade 3 performance, although it was found that SES was more predictive of outcomes, other contributing factors that are more amenable to change, including early biological adversity and program delivery in the early stages of development, are still important to address and will also contribute to better school performance (Brownell et al., 2012).

Evidently, early periods are influential on later success, in both school and health. Given the evidence on the rates of return to human capital investment, currently, there is a mismatch between opportunity and investment, as rates to return are greater during the early childhood stage (Heckman, 2006). Among the key recommendations set forth by the Government of Manitoba in the 2013 Early Childhood Development framework was to continue to increase awareness of the importance of early childhood development and also to address the social determinants of health, both of which this study sets out to do (Government of Manitoba, 2013). Research has shown that decreasing early vulnerability of children from its current rate of 25%

down to 10% has the potential to produce substantial long-term economic gains, reduce crime, and promote positive school achievement (Kershaw et al., 2010). If this population of late preterm children is indeed contributing to the number of children who enter school in a vulnerable state, targeting them to increase their supports and investing in them early may be a worthwhile and fiscally responsible investment, particularly if these children are already being reached through other programs in Manitoba.

## 2.7 Gaps in the literature

The purpose of the current study was to examine a range of health and educational outcomes among children born late preterm (34-36 weeks) and at term (39-41 weeks) using a large population-based cohort based in urban Manitoba. The literature reviewed demonstrated that many of the previous studies did not adequately adjust for the socioeconomic risk differences between late preterm and term infants and many included the early term population in the term comparison group. The addition of a large range of medical and social risk components when examining outcomes for this population at the population level is an important addition to the literature, and allowed for an examination of whether children born late preterm perform poorer due to prematurity itself, or due to the characteristics of this population. It also allowed for an examination of whether the effect of prematurity diminishes over time or remains a prominent contributor to outcomes. A socioeconomic approach further served to obtain a more comprehensive understanding of the multiple factors that affect child health in Manitoba and to identify which groups of children are at greatest risk for poor outcomes. To date, early childhood outcomes in this population had not been examined to this magnitude within Canada, and never within Manitoba.

# Chapter 3: Methods

## 3.1 Overview

Data maintained in the Population Health Research Data Repository, housed at the Manitoba Centre for Health Policy (MCHP), were used to examine the proposed research questions. This included data collected by the Healthy Child Manitoba Office (HCMO), Manitoba Family Services, Manitoba Education and Advanced Learning, Manitoba Jobs & the Economy, the Canada Census, and Manitoba Health, Healthy Living & Seniors. The study relied on kindergarten (the Early Development Instrument) and grade 3 educational assessments to examine school readiness and performance, while a number of administrative databases were used to assess health and neurodevelopmental outcomes, including health care utilization at ages 4 and 7, lower respiratory tract infections (LRTIs), asthma, and ADHD. Finally, education records were used to examine grade repetition and receipt of special education funding. Multiple logistic regression modeling was used to examine the impact of prematurity on these outcomes throughout early childhood among children born late preterm and term, after controlling for medical and social factors, including variables at the maternal, child and family levels.

## 3.2 Study Design and Population

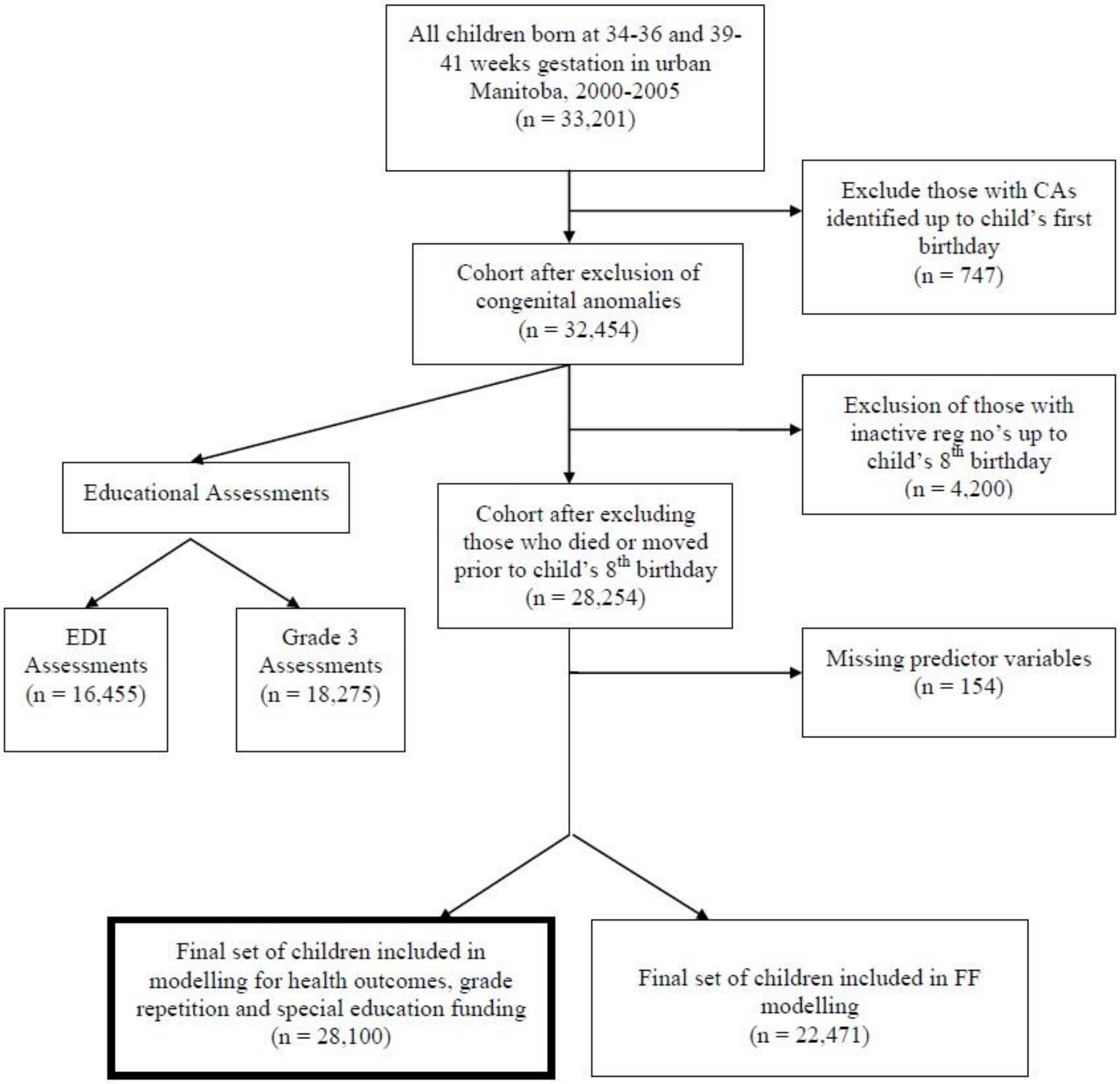
The population in the current study consisted of all live-born children born late preterm (34-36 weeks gestation) and at term (39-41 weeks gestation) between 2000 and 2005 in urban Manitoba (N=28,100). For the purposes of this study, urban Manitoba referred to the cities of Brandon and Winnipeg. Restricting the analysis to urban Manitoba was done to allow for more complete use of the Families First (FF) and education data, which are not consistently collected in First Nations communities due to federal jurisdiction.

Study exclusion criteria included children with significant congenital anomalies, children who died or moved out of province before their 8th birthday, and those with missing predictor variables. Children with significant congenital anomalies (CAs) (n=747) were identified through hospital abstracts from the birth hospitalization up to the child's first birthday using an adapted list from Ruth et al. (2010). The list was adapted under the guidance of a neonatologist to include CAs that would impact child health, educational and developmental outcomes in later childhood, and exclude CAs that are typically resolved within the first year of life. With the exception for use with educational outcomes, 13.10% (n=4200) were identified to have inactive registration numbers at any point up to the child's 8th birthday, and thus were excluded from the analysis. Of these, 0.19% (n=61) had died. Finally, those with missing predictor variables (n=154) were excluded from the analysis, leaving a final study sample of 28,100 to be included in the full cohort models (see figure 1 below).

A second set of exclusion criteria was used for outcomes that were based on educational assessments (EDI and grade 3 reading and numeracy assessments). For these, the exclusion criterion of continuous registration with Manitoba Health was not required; but rather, all those with educational assessments were included. Those with significant CAs and missing predictor variables were excluded. Of the cohort without CAs or predictor variables, 16,455 had EDI assessments available, 18,275 had grade 3 assessments available, and 28,100 were assessed for grade repetition and receipt of special education funding. Given that the EDI is only conducted every second year, there are only half the EDI assessments as would be expected. The number of grade 3 assessments available was also reduced, as they were not available for the 2000 birth cohort who took part in the 2008 pilot assessment.

Similar to the Manitoba Centre for Health Policy's Perinatal Report (Heaman et al., 2012), analyses were also run using the proportion of the cohort who received a Baby First (BF) (2000-2002) or FF (2003-2005) screen (n=22,471) to allow for the inclusion of a broader range of social predictor variables. As has been previously noted, not all Manitoban women receive the screen, and those not receiving tend to be more vulnerable (Heaman et al., 2012). Although this study was initially restricted to urban Manitoba to allow, in part, for better coverage of BF/FF screening, there was a large number of women in urban Manitoba who were not screened (n=5,629 or 20.22%) or who were missing values on their screen, which was much higher than anticipated.

*Figure 1: Flow diagram of study population*



Using a retrospective cohort study design, the association of GA and SES on later child outcomes was examined. The birth cohorts selected allowed follow up of the infants to at least 8 years of age. They also correspond to the biennial EDI assessments, which occurred in the 2005/06, 2006/07, 2008/09 and 2010/11 school years. Data for grade repetition, receipt of specialized funding and ADHD diagnosis were also available for these birth cohorts, up to 2011/12.

## 3.3 Databases

This study utilized information from several different databases housed in the Population Health Research Data Repository at MCHP. The Repository is a comprehensive collection of administrative, survey, registry and clinical data sets maintained by Manitoba Health, Healthy Living & Seniors, which cover the entire population of Manitoba. The data at MCHP are de-identified and can be linked for analysis using an encrypted Personal Health Identification Number (PHIN). The ability to access multiple datasets at MCHP and link these over time and across sectors make this a highly feasible and unique setting to assess the multiple domains in which children born late preterm may be affected in the longer-term at a population level. The validity of the Repository for conducting population-based analysis has been previously reported (Brownell, Roos, MacWilliam, Leclair, Ekuma & Fransoo, 2010; Jutte, Brownell, Roos, Schippers, Boyce, & Syme, 2010; Jutte, Roos, & Brownell, 2011; Roos, Gupta, Sodeen, & Jebamani, 2005; Roos, Menec, & Currie, 2004; Roos & Nicol, 1999). The following datasets were used in this study:

*Population Registry.* The registry was used for linking databases. The population registry includes every person who has registered for the Manitoba Health Services Insurance Plan since 1970. All children can be linked to other databases using their scrambled PHIN.

*Hospital Discharge Abstracts.* Hospital Abstracts include demographic and clinical information collected at time of discharge from hospital. This includes ICD-9-CM (up to March 31, 2004) and ICD-10 (from April 1, 2004 onward) diagnostic codes and service dates used to develop indicators of health service use and health status. Information required for the current study included the health of the child at birth (NICU admission, length of stay at birth, size for GA, GA, and utilization of hospital services), the health of the mother prior to birth (gestational diabetes), and a number of indicators developed to assess child health status between 1 and 8 years of age. These variables are described in greater detail below.

*Midwifery Discharge Summary Report Data.* This database contains summary information for all Manitoban women receiving care from a midwife and includes information relating to demographics, birth outcomes and consults. It was used to identify women who gave birth and received care from a midwife.

*Drug Program Information Network (DPIN) Data.* The Drug Program Information Network (DPIN) database in maintained by Manitoba Health, Healthy Living & Seniors and contains transaction-based prescription drug claims from community pharmacies in Manitoba. Using dispense dates and prescriptions received, information from this database was utilized to develop the health related dependent variables and the maternal diabetes variable described below, in conjunction with Medical Services Data and Hospital Discharge Abstracts.

*Medical Services Data.* Medical claims are claims for services provided by physicians and submitted to Manitoba Health, Healthy Living & Seniors for payment among fee-for-service physicians or as shadow billing for physicians on alternate payment plans to provide a record of the visit. This database contains information about ambulatory services provided and was used in conjunction with hospital abstracts and pharmaceutical claims to develop the child health related dependent variables and the maternal diabetes independent variable described below.

*Baby First and Families First Screening.* The BF Screen includes families with children born between January 1, 2000 and December 31, 2002, while the FF Screen includes families with children born January 1, 2003 and onwards. The BF/FF Screening program is a universal screening program conducted by public health nurses in Manitoba to collect information about parental and child biological, social and demographic risk factors. Screening is voluntary, and thus, not all Manitoban families are captured with the screen. Furthermore, the screen is not administered to families living in federal jurisdictions (Brownell, Santos, Chartier, Girard, & Roos, 2011). Several differences exist between the two sets of forms, most notably for this study, questions about drug and alcohol use during pregnancy are presented together in the BF Screen and separately in the FF Screen. Information extracted from these databases includes variables on substance use during pregnancy (alcohol or drug use), smoking during pregnancy, not graduating high school by time of child's birth, and lone parent status.

*Income/Employment Assistance Program.* This dataset is maintained by Manitoba Jobs & the Economy and provides information on individuals and families who receive financial assistance from the Employment and Income Assistance (EIA) Program. This data set was used to extract family receipt of income assistance when children were aged 4 and 7, an individual level measure of SES.

*Early Development Instrument Database.* The Early Development Instrument (EDI) is a province-wide assessment of school readiness, conducted biennially by kindergarten teachers in Manitoba. All kindergarten students at participating schools are included. This dataset includes a binary variable to indicate readiness for kindergarten in 5 domains: physical health and well-being, social competence, emotional maturity, language and cognitive development, and communication skills and general knowledge.

*Enrollment, Marks and Assessments Data.* Maintained by Manitoba Education and Advanced Learning, this dataset provides information on school enrollment, courses, marks, standards tests, level of funding, and educational assessments for all children attending a Manitoba school from Kindergarten to Grade 12. This dataset was used to identify children who received special education funding, repeated kindergarten or grade 1, and for grade 3 reading and numeracy assessment information.

*Child and Family Services Information System.* The Child and Family Services Information System (CFSIS) database identifies all families who have received support or protection services from the Child Protection and Support Services division of Manitoba Family Services and Housing. For this study, families receiving protective or support services and all children in care were identified.

*Census.* Public access Census data were utilized to attach an area-level measure of SES to cohort members using the mean household income of residents within a dissemination area. Dissemination areas include between 400 and 700 persons. Analyses have demonstrated that area-level measures of SES are well correlated with individual-level measures (Mustard, Derksen, Berthelot, & Wolfson, 1999).

### 3.4 Independent variables

The primary independent variable of interest, GA at birth, was calculated using the baby to mother in-hospital linked file, a subset of the Hospital Discharge Abstracts data. From this file, GA in weeks is approximated based on the time from the first day of the woman's last menstrual period to the date of birth. For the purposes of this study, GA was grouped as "late preterm" (34-36 weeks gestation) and "term" (39-41 weeks gestation). These categories were used as a dichotomous variable during analysis. Because studies have shown that infants born early term (37-38 weeks) differ from those born at term, they were not included in the term comparison group.

In addition to the late preterm variable, other variables used in either descriptive statistics and/or modeling are described below. The variables were divided into three levels for descriptive purposes (maternal, child and family level variables) and into up to four levels for modeling (base, medical, social, and BF/FF variables).

### Maternal Variables

*Mother's Age at First Birth (categorical).* The age of the mother at time of first birth was extracted from the population registry and was grouped into six categories: <18, 18-19, 20-24, 25-29 (reference category), 30-34 and 35+.

*Maternal Diabetes (binary).* A woman was considered to have maternal diabetes if she had one or more hospitalizations or two or more physician claims with a diagnosis code ICD-9-CM: 250 or ICD-10-CD-CA: E10-14, a hospitalization with a gestational diabetes code in the gestation period (ICD-9-cm: 648.8, ICD-10-CA:024), or one or more prescriptions for diabetic drugs (Heaman et al., 2012) three years prior to birth and up to the birth of the baby. This information was obtained using hospital abstracts, physician claims and pharmaceutical claims.

*Mother Graduated High School at Time of Child's Birth (categorical).* As per responses from the BF and FF screening form, this included women giving birth with less than or having a grade 12 education. Those with a missing response variable, but not missing the full screen, were categorized as 'missing'.

*Substance Use During Pregnancy (categorical).* A composite measure of alcohol and illicit drug use during pregnancy was developed and included women who self-reported consuming alcohol and use of substances considered illegal and punishable within the criminal code during pregnancy on the BF/FF screening form. Those with a missing response variable, but not missing the whole screen were coded as 'missing'.

*Smoking During Pregnancy (categorical).* This indicator includes women who self-reported smoking during pregnancy on the BF/FF Screening Form. Again, those missing a response, but not the whole screen, were categorized as 'missing'.

### Child Variables

*Age in months (continuous).* For the purposes of controlling for confounding for the EDI assessment outcomes, age in months was calculated using birthdate from the population registry and date of assessment from the EDI database, and entered as a continuous variable. The midpoint of the school year (February 15th) was assigned for those with missing or improbable EDI assessment dates.

*Sex (binary).* The biological sex of the child was identified using the population registry.

*Size for GA (categorical).* Size for GA refers to a measure of fetal growth that is developed using a neonate's GA, biological sex, and birth weight. This indicator was classified into 3 categories: small for gestational age (SGA), which refers to infants who are at or below the 10th percentile in birth weight from an infant population of the same sex and GA; large for GA (LGA), referring to infants at or above the 90th percentile; and appropriate for GA (AGA) for those whose birth weight was between the 10th and 90th percentiles for the infant's GA and sex. This classification was based on the population-based Canadian reference for birth weight for GA (Kramer et al., 2001).

*Neonatal Intensive Care Unit (NICU) admission at birth (binary).* A live-born baby was considered to have had admission to the NICU if there was evidence of any admission to a special care unit (SCU) during the birth hospitalization stay, as was noted by the presence of SCU unit 50 or 98 on hospital abstracts (Heaman et al, 2012). This was initially meant to differentiate complicated and uncomplicated preterm infants, however, a large portion of late preterm infants spent time in the NICU. In addition, given that infants born at 34 weeks gestation will have been admitted to an NICU at birth by protocol, it was concluded that this wouldn't serve as a sufficient proxy of severity, but rather, was used for descriptive purposes.

*Length of stay at birth (continuous).* The continuous variable, length of stay at birth, was calculated as the number of days of care from the date of birth to discharge date using data from the hospital abstracts database. This also was initially meant to serve as a proxy of severity.

*Multiple birth (binary).* Multiple birth referred to the birth of two or more children during a single delivery with gestation 20 weeks or more, as was indicated based on the presence of ICD-9-CM and ICD-10-CA codes of V31-V37 or O84 (Heaman et al., 2012).

*AGD sum (continuous).* The Aggregated Diagnostic Grouping (ADG) sum variable was used as a measure of sickness in the first year of life, counting all diagnoses received from the birth hospitalization through to the child's first birthday. Based on the Johns Hopkins ACG® Case-Mix System, individuals are assigned an ADG if they have one or more of the ADG's constituent diagnoses coded on at least one physician claim or hospital separation record over 1 year (Johns Hopkins School of Public Health, 2009). According to MCHP (2013), ICD-9 and ICD-10 codes are assigned to one of 32 different ADGs based on five clinical and expected utilization criteria, including duration, severity, diagnostic certainty, etiology, and specialty care involvement. ADG groupings that were removed from the sum include those relating to asthma, prevention/administration, pregnancy, and dental. In addition, ICD codes relating to birthweight, GA, birth type, and routine circumcision were removed to eliminate redundancy and to capture sickness.

### Family Variables

*4+ Children in the family (binary).* Family size was first measured based on counting the number of children born to a mother and/or counting the number of children with the same Manitoba Health Registration Number at the same date(s) by matching the mother and baby records. The mother/baby linkage file and the Manitoba Health Insurance Registry Data was then used to calculate number of children aged 0-19 years who are believed to live together in one household. These values were then dichotomized into two categories: whether the family had 4 or more children or not.

*Lone parent status (categorical).* Lone parent status was derived as per Heaman et al. (2012), using self-identification of sole primary care giver for her child (including unmarried, separated, widowed, divorced, and common-law relationships of less than one year) from the BF/FF Screen. For those with missing values, but not missing the entire screen, they were entered into a third 'missing' category.

*Family received support or protection services (binary).* This was a dichotomous measure that refers to the family receipt of support or protection services from CFS at any point up to the child's 8th birthday. Identified using CFSIS, this involves children who remain in the home while the family received voluntary or protection services.

*Children in Care (binary).* This was a dichotomous measure that refers to the removal of the child from the family home and placement in the care of CFS at any point up to the child's 8th birthday. Identified using CFSIS, this involves children who are removed from their families due to concerns about improper provision of care.

*Income Quintile (categorical).* Income quintile refers to an area-level measure of SES, which was developed by assigning average household income from the 2006 Statistics Canada

Census to dissemination areas. Disseminations areas were then grouped into 5 income quintiles containing approximately 20% of the population. Income quintile was measured at 4 years of age to deal with discrepancies that may arise from SES changes between birth and 8 years of age.

*Receipt of Income Assistance (IA) (categorical).* This variable includes individuals who received IA for one month or more and is categorized as a binary yes/no variable. Family receipt of income assistance was calculated at both 4 and 7 years of age using the Social Allowances Management Information Network (SAMIN) and acts as an individual measure of SES. The provincial Employment and Income Assistance program is a last resort for people who need help to meet basic personal and family needs and applicants must demonstrate financial need for the monthly costs of basic needs such as food, clothing, personal needs and household supplies, and housing (rent) and utilities (Brownell et al., 2007).

## 3.5 Dependent Variables

### Health Outcomes

Late preterm and term infants were assessed on a number of different health and educational/neurodevelopmental outcomes between 1 and 8 years of age, including:

***Lower Respiratory Tract Infections (LRTIs).*** The LRTI indicator was developed based on a modified definition used by Brownell et al. (2007), which included children between 1 and less than 5 years of age with at least one hospitalization for an LRTI based on their primary diagnosis from hospital abstracts.

***Morbidity at 4 and 7 years of age.*** A measure of “morbidity” or health care resource utilization was developed using Aggregated Diagnosis Groups™ (ADGs™) codes created with the Johns Hopkins Adjusted Clinical Group® (ACG®) Case-Mix System version 9, which ranks each child’s overall sickness based on all diagnoses attributed to them during medical visits and hospitalizations during the preceding year. These diagnoses are then ranked based on intensity or costs to the system into a resource utilization band (RUB) value. A binary measure was developed which included: “low morbidity” (a composite measure of the RUB values 0-non-user, 1-healthy user, and 2-low morbidity) and moderate to high morbidity (a composite measure of RUB values 3-Moderate Morbidity, 4-High Morbidity, and 5-Very High Morbidity). RUB groupings were assigned for each child based on diagnoses between age 3-4 and 6-7, and thus, “morbidity” or resource usage was reported at both ages 4 and 7.

***Asthma.*** An asthma diagnosis was measured as per Chartier et al. (2012) and Brownell et al (2012) as one of the following within a 2-year period: 1 or more physician visits with ICD-9-CM of 493, 1 or more hospitalizations with ICD-9-CM and ICD-10-CA codes of 493 or J45, or 1 or more prescriptions related to asthma (R03BA01, R03BA08, R03BA03, R03BA02, R03BA06, R03AC04, R03AC02, R03AB02, R03AC03, R03AC12, R03AC13, R03AK06, R03AK07, R03BB01). Asthma was measured between 6 and 8 years of age.

***Attention Deficit Hyperactivity Disorder (ADHD).*** ADHD was defined as per Brownell et al. (2008 and 2012) based on 1 or more hospitalizations with a diagnosis of hyperkinetic syndrome (ICD-9-CM and ICD-10-CA codes 314 or F90), or 1 or more physician visits with a diagnosis of hyperkinetic syndrome (314), or 2 or more prescriptions for ADHD drugs without a diagnosis of conduct disorder, disturbance of emotions or cataplexy/narcolepsy. ADHD was measured between 5 and 8 years of age.

### Educational Outcomes

***Early Development Instrument (EDI) Domains.*** School readiness was measured using the Early Development Instrument (EDI), a population based community level teacher assessed measure of children’s readiness to learn in 5 domains: physical health and well-being, social competence, emotional health/maturity, language and cognitive development, and communication skills and general knowledge. Children were classified as being “not ready” in a given EDI domain if they scored below the 10th percentile cut-off score, based on Canadian norms for that domain. In addition to examining readiness in each of the 5 domains using a binary yes/no variable, the main measures reported were “not ready” in one or more domain and “not ready” in two or more domains. EDI scores are reported for all individuals who had a recorded teacher assessment during four evaluation years: 2005/06, 2006/07, 2008/09, and 2010/11.

***Grade Repetition.*** Grade repetition was defined as having been enrolled in the same grade for two or more consecutive academic years. Students were followed to the second grade (grade repetition in kindergarten or grade 1) to ensure each birth year had the same follow up period.

***Receipt of Special Education Funding.*** Receipt of special education funding included the receipt of funding for students who required individualized instruction for a major portion of the school day (Level II funding) and specialized instruction for the entire day (Level III funding). Level II and III funding were combined to a binary yes/no variable relating to receipt of special education funding.

***Grade 3 Reading Assessments***. All students enrolled in publically provincially funded schools are assessed in their grade 3 year on three different reading competencies: 1) reflects on and set reading goals, 2) uses strategies during reading to make sense of texts, and 3) demonstrates comprehension (Brownell et al., 2012). Similar to Brownell et al. (2012), only the second and third competencies were used to measure grade 3 reading. Students are then categorized according to one of the four levels of achievement standards on each competency: 1) meeting expectations, 2) approaching expectations, 3) needs ongoing help, and 4) out of range. Achievement was then dichotomized into “meeting expectations in both competencies=0” and “Approaching or not meeting expectations in one or both competencies=0,” a combined measure of levels 2-4 noted above. This measure included all children within the initial cohort who were assessed in their grade 3 year, but excluded assessments from the 2008/09 pilot year, as this school year contained only 10% of the entire population of grade 3 students.

***Grade 3 Numeracy Assessments.*** Students in grade 3 are assessed on four different numeracy competencies: 1) predicts an element in a repeating pattern, 2) understands that the equal symbol represents an equality of the terms found on either side of the symbol, 3) understands that a given whole number may be represented in a variety of ways, and 4) uses various mental math strategies to determine answers to addition and subtraction questions up to the number 18 (Brownell et al., 2012), which are focused on algebraic reasoning and number sense. Students are then categorized into one of the four achievement levels based on the teachers’ assessment of their performance. Similar to reading assessments, students were grouped into “meeting expectations in all four domains” and “those not meeting expectations in all four domains”. Again, the 2008/09 pilot year assessments were excluded from the analysis, and thus, years 2009/10 – 2012/13 were included.

## 3.6 Rationale for Independent Variables

The inclusion of the independent variables noted above was based on support from the literature. Previous studies have identified sex, size for GA, maternal smoking, maternal education and unemployment as strong predictors of later childhood development (Chen & Millar, 1999; Fily, Pierrat, Delporte, Breart, & Truffert, 2006; Shah, Kahan, & Krauser, 1987; To et al., 2004). Lone parent status and material deprivation have also been shown to be predictive of poorer health, educational and behavioral outcomes in childhood (Santos et al., 2012; Spencer, 2005a; Spencer, 2005b). Diabetes in pregnancy has also been associated with lower grades and less school completion among offspring (Dahlquist & Kallen, 2007), neurodeveloplmental effects in explicit memory recall (Deboer et al., 2005), increased risk of ADHD (Nomura et al., 2012), increased rates of hospital use (Aberg & Westbom, 2001; Ruth, 2010) and increased rates of diabetes and obesity in childhood (Lacroix, Kina, & Hivert, 2013). The impact of maternal substance use on later childhood outcomes has been associated with poorer intellectual, emotional-behavioral and developmental outcomes and higher prevalence of asthma (Bennet, Bendersky, & Lewis, 2002; Faden & Graubard, 2000; Jaakkola & Gissler, 2004). Pregnancy related variables were not included in the models, as the outcome of interest is later childhood health, educational and neurodevelopmental outcomes. These independent variables are also known predictors of later outcomes (Baron et al., 2011; McGowan et al., 2012). Maternal predictors of EDI vulnerability, and thus educational outcomes of interest, include mother's age at first birth, family receipt of IA, socioeconomic adversity, and marital status (Santos et al., 2012). Infant and child predictors of EDI vulnerability include involvement in CFS, infant's size for GA, sex, NICU admission and LOS at birth (Santos et al., 2012). Furthermore, Brownell et al. (2012) identified mother's age at first birth, sex, involvement in CFS, family size and SES as strong predictors of educational outcomes in kindergarten and grade three.

### 3.7 Analysis

Statistical analyses were completed using SAS® 9.3. Univariate analysis was first conducted comparing the late preterm population to children born at term. This included the testing of between-group differences for binary and categorical independent variables using chi-square tests and central tendency measures (mean, median, range, and standard deviation (SD)) for continuous independent variables. Between-group differences were also calculated for each outcome variable using chi-square tests.

Multiple logistic regression models were then built to examine the odds of each health and educational outcome noted above among former late preterm and term infants. To examine whether there was a measureable difference in health status and educational/developmental progress attributable to prematurity at 34-36 weeks gestation, confounding variables known to have an impact on the outcomes of interest were included in an attempt to ensure comparability between the late preterm and term groups. Control variables were chosen based on the use of causal diagrams and discussion at the University of Manitoba’s Biostatistical Consulting Unit and are also supported by literature that suggests they may be predictive of the later childhood outcome variables of interest. These variables were then further tested for their association with the outcomes using the univariate methods noted above. The potential for multicollinearity between independent variables was tested using the phi-coefficient, a measure of association for dichotomous variables (Ekstrom, 1999). High multicollinearity was found between the BF/FF variables when including those with a missing screen and missing value in the missing category. Once those missing the full screen were removed, multicollinearity changed to well below a +0.50 cut-off. A phi-coefficient of -0.30 to +0.30 indicates little or no association, one of +0.30 to +0.70 indicates a weak positive association, and +0.70 to +1.0 indicates a strong positive association, or in other words, multicollinearity. Associations were also tested between predictor and outcome variables.

As noted above, variables of interest were entered into the model in 3 steps: base variables (age and sex adjusted), biological or medical variables, and social variables. Similar to

Heaman et al. (2012), analyses were also run on those with a BF or FF screen, in which case screen variables were then added into the model as a fourth step.

Finally, a sensitivity analysis was run to examine the impact of including multiple births in the analysis. Given that the effect on the models was minimal whether multiples were included or excluded, multiple births were kept in the analysis and controlled for in modeling.

## 3.7 Ethical Considerations

Ethical approval was obtained from the University of Manitoba's Health Research Ethics Board for the purpose of conducting a retrospective chart review for secondary data use. Approvals were also obtained from the Manitoba Health Information Privacy Committee, Healthy Child Manitoba, Manitoba Family Services, Manitoba Education and Advanced Learning, and Manitoba Jobs and the Economy. Upon receiving the appropriate approvals, a researcher agreement was submitted and data necessary for this study were extracted by an analyst at MCHP.

In accordance with MCHP policies, data are presented in summary or aggregated form only, and groupings that result in one to five individuals were suppressed to ensure anonymity. All data were de-identified prior to access and all linkages were done using a scrambled PHIN. Data handing and statistical analysis was conducted at MCHP, a tightly secured and restricted environment.

# Chapter 4: Results

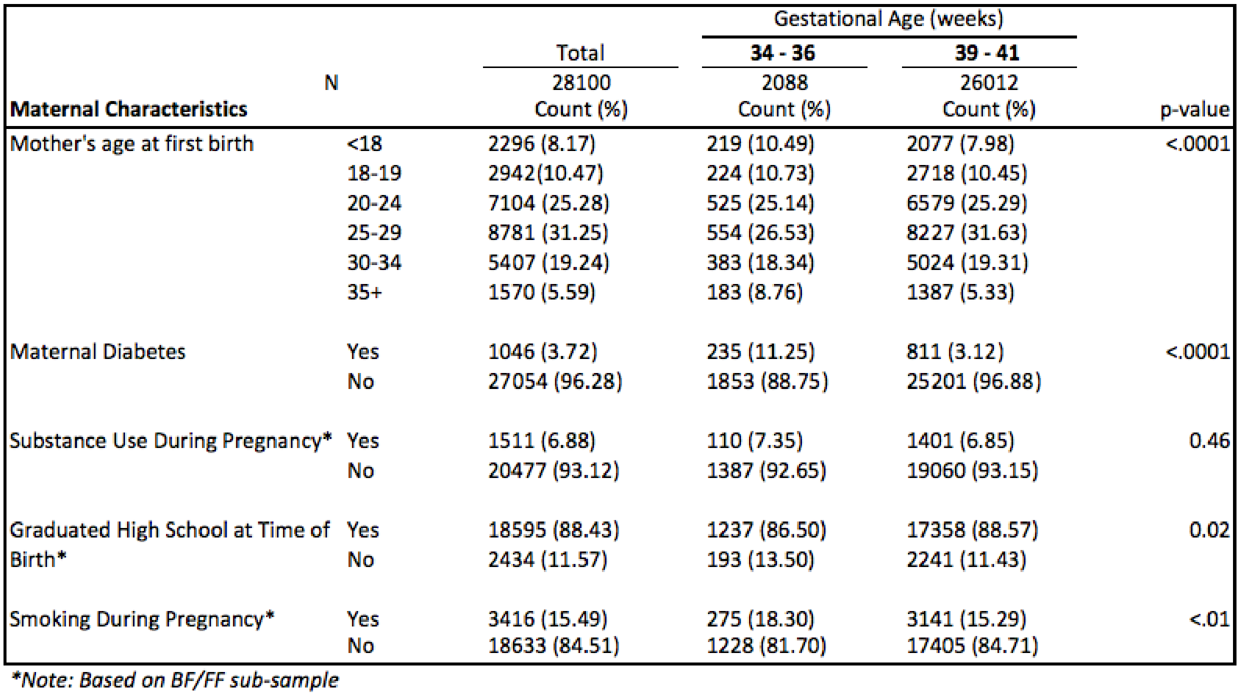
## 4.1 Study Population

The final analyses included 28,100 live-born infants born to mothers in Winnipeg and Brandon between 2000 and 2005 (see Figure 1). Of these, 7.43% (n=2,088) were born late preterm (34-36 weeks gestation) and 92.57% (n=26,012) were born at term (39-41 weeks gestation).

## 4.2 Descriptive Statistics

Comparison of child, maternal and family related variables are presented overall and by GA grouping. As seen in tables 1 to 3, the late preterm population is, in most cases, significantly different from those born at term and appears to be a more ‘at-risk’ group. Chi-square testing of maternal characteristics demonstrates that children born late preterm tend to have a mother whose first birth was at a younger (10.49% vs. 7.98% at less than 18 years of age) or older (8.76% vs. 5.33% at 35 years or above) maternal age. They were also more likely to be born to a mother who had maternal diabetes (11.25% vs. 3.12%, p<.0001), who smoked during pregnancy (18.30% vs 15.29%, p <.01), or who hadn’t graduated from high school at the time of birth (13.50% vs. 11.43%, p <.01). There were no statistically significant differences between the two groups on the use of alcohol or illicit drug use during pregnancy.

*Table 1: Maternal Characteristics for Children born Late Preterm (34—36 weeks GA) and Term (39-41 weeks GA)*



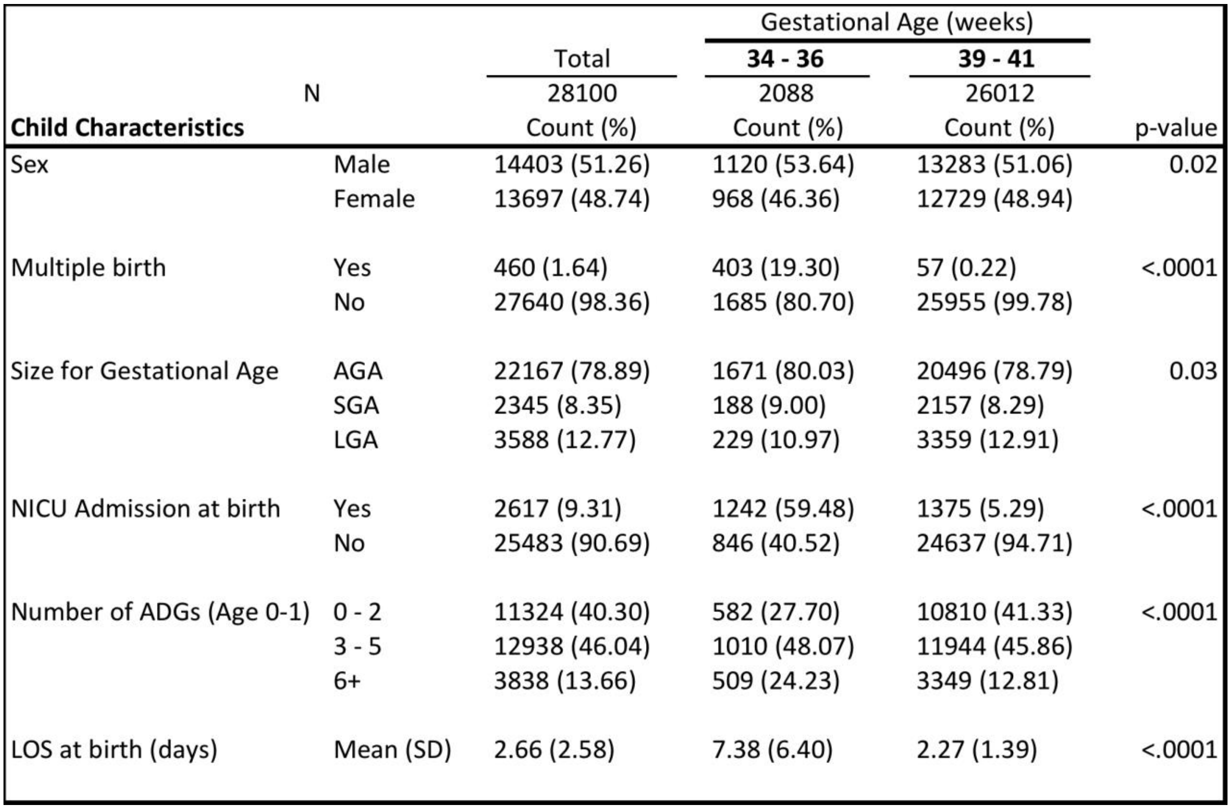
| | | | Gestational Age (weeks) | | |
|---|---|---|---|---|---|
| | | Total | **34 - 36** | **39 - 41** | |
| | N | 28100 | 2088 | 26012 | |
| **Maternal Characteristics** | | Count (%) | Count (%) | Count (%) | p-value |
| Mother's age at first birth | <18 | 2296 (8.17) | 219 (10.49) | 2077 (7.98) | <.0001 |
| | 18-19 | 2942(10.47) | 224 (10.73) | 2718 (10.45) | |
| | 20-24 | 7104 (25.28) | 525 (25.14) | 6579 (25.29) | |
| | 25-29 | 8781 (31.25) | 554 (26.53) | 8227 (31.63) | |
| | 30-34 | 5407 (19.24) | 383 (18.34) | 5024 (19.31) | |
| | 35+ | 1570 (5.59) | 183 (8.76) | 1387 (5.33) | |
| Maternal Diabetes | Yes | 1046 (3.72) | 235 (11.25) | 811 (3.12) | <.0001 |
| | No | 27054 (96.28) | 1853 (88.75) | 25201 (96.88) | |
| Substance Use During Pregnancy* | Yes | 1511 (6.88) | 110 (7.35) | 1401 (6.85) | 0.46 |
| | No | 20477 (93.12) | 1387 (92.65) | 19060 (93.15) | |
| Graduated High School at Time of Birth* | Yes | 18595 (88.43) | 1237 (86.50) | 17358 (88.57) | 0.02 |
| | No | 2434 (11.57) | 193 (13.50) | 2241 (11.43) | |
| Smoking During Pregnancy* | Yes | 3416 (15.49) | 275 (18.30) | 3141 (15.29) | <.01 |
| | No | 18633 (84.51) | 1228 (81.70) | 17405 (84.71) | |

**Note: Based on BF/FF sub-sample*

**Child Characteristics.** Compared to children born at term, children born late preterm were more likely to be male (p=0.02) and have a longer mean length of stay at birth (7.38 days compared to 2.27 days, p<.0001) (Table 2). The majority of multiple births were among children born late preterm (19.30% compared to 0.22% for term births, p <.0001) and 59.48% spent time in the NICU at birth, compared to only 5.29% of those born at term (p <.0001). Size for GA demonstrates that 80.03% of the late preterm population were born at an appropriate size for GA, slightly more than those born at term (78.79%). Furthermore, children born late preterm were more likely to be SGA (9% vs 8.29%) whereas those born at term were more likely to be LGA (12.91% vs 10.97%). Finally, using number of ADGs in the first year of life as a measure of sickness, term infants were more likely to have fewer than 3 diagnostic groups assigned (41.3% and 27.7% for term and late preterm respectively), whereas late preterm infants were more likely
]

to be assigned to 6 or more groups (24.23% of late preterm infants compared to 12.81% of term infants), which is assumed to be a high level of morbidity during the first year of life.

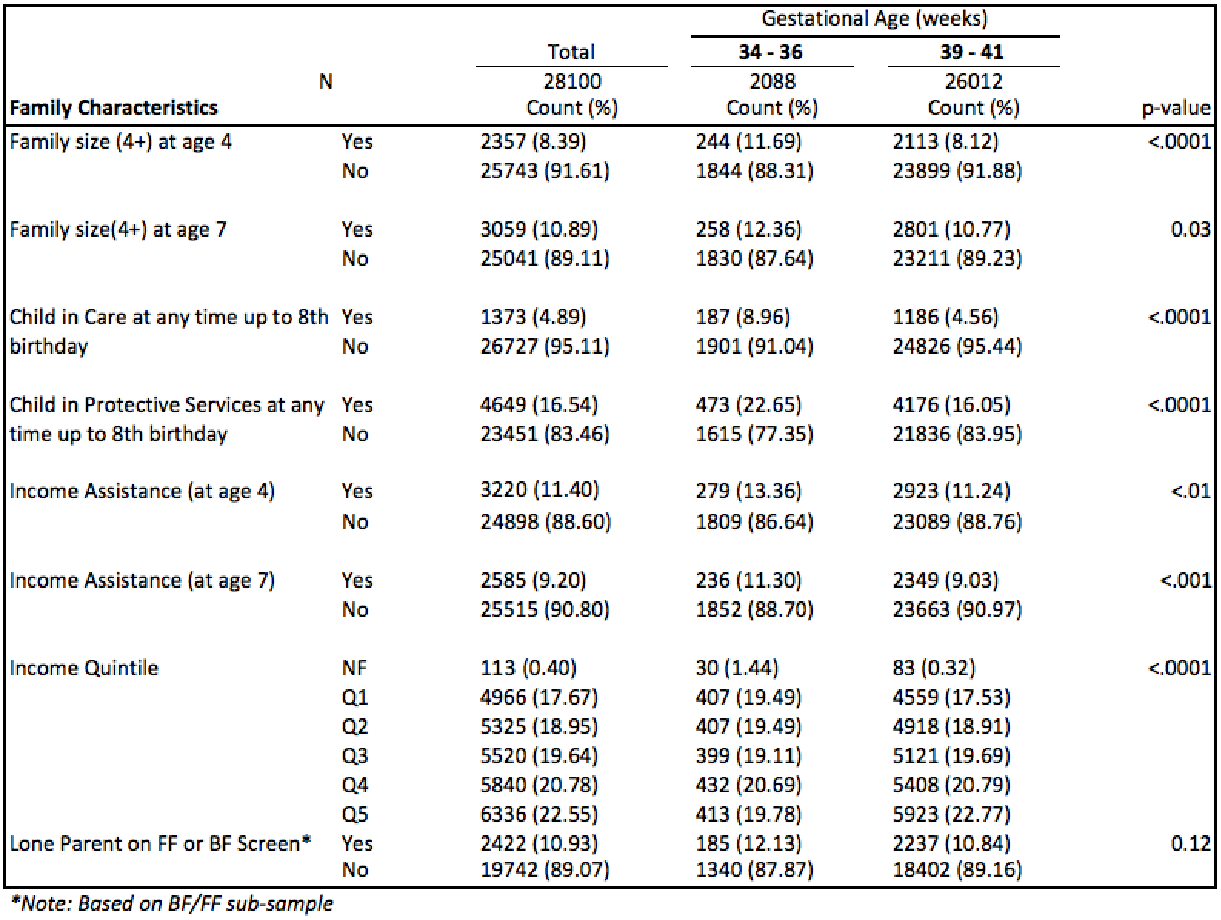
*Table 2: Child Characteristics for Children born Late Preterm (34—36 weeks GA) and Term (39-41 weeks GA)*



| | | | Gestational Age (weeks) | | |
|---|---|---|---|---|---|
| | | Total | **34 - 36** | **39 - 41** | |
| | N | 28100 | 2088 | 26012 | |
| **Child Characteristics** | | Count (%) | Count (%) | Count (%) | p-value |
| Sex | Male | 14403 (51.26) | 1120 (53.64) | 13283 (51.06) | 0.02 |
| | Female | 13697 (48.74) | 968 (46.36) | 12729 (48.94) | |
| Multiple birth | Yes | 460 (1.64) | 403 (19.30) | 57 (0.22) | <.0001 |
| | No | 27640 (98.36) | 1685 (80.70) | 25955 (99.78) | |
| Size for Gestational Age | AGA | 22167 (78.89) | 1671 (80.03) | 20496 (78.79) | 0.03 |
| | SGA | 2345 (8.35) | 188 (9.00) | 2157 (8.29) | |
| | LGA | 3588 (12.77) | 229 (10.97) | 3359 (12.91) | |
| NICU Admission at birth | Yes | 2617 (9.31) | 1242 (59.48) | 1375 (5.29) | <.0001 |
| | No | 25483 (90.69) | 846 (40.52) | 24637 (94.71) | |
| Number of ADGs (Age 0-1) | 0 - 2 | 11324 (40.30) | 582 (27.70) | 10810 (41.33) | <.0001 |
| | 3 - 5 | 12938 (46.04) | 1010 (48.07) | 11944 (45.86) | |
| | 6+ | 3838 (13.66) | 509 (24.23) | 3349 (12.81) | |
| LOS at birth (days) | Mean (SD) | 2.66 (2.58) | 7.38 (6.40) | 2.27 (1.39) | <.0001 |

**Family Characteristics.** Examination of individual and area level measures of family income indicate that children born late preterm are significantly more likely to come from families who received income assistance at age 4 (13.36% vs. 11.24%) and age 7 (11.30% vs. 9.03%) compared to those born at term (Table 3). Although area-level measures of SES were fairly equal for both groups across income quintiles 2 to 4, children born late preterm had more families from quintile 1 (19.49% vs. 17.53%) and fewer in the highest income quintile (19.78% vs. 22.77). Late preterm children were almost twice as likely to have been removed from their family home and in CFS custody at any time up to their 8th birthday (8.96% vs. 4.56%). They were also more likely to be in families receiving voluntary and protection services (22.65% vs. 16.05%). Finally, children born late preterm tended to come from larger families at both 4 and 7 years of age (p <.0001). Groups were not significantly different on lone parent status.

*Table 3: Family Characteristics of Children born Late Preterm (34—36 weeks GA) and Term (39-41 weeks GA)*

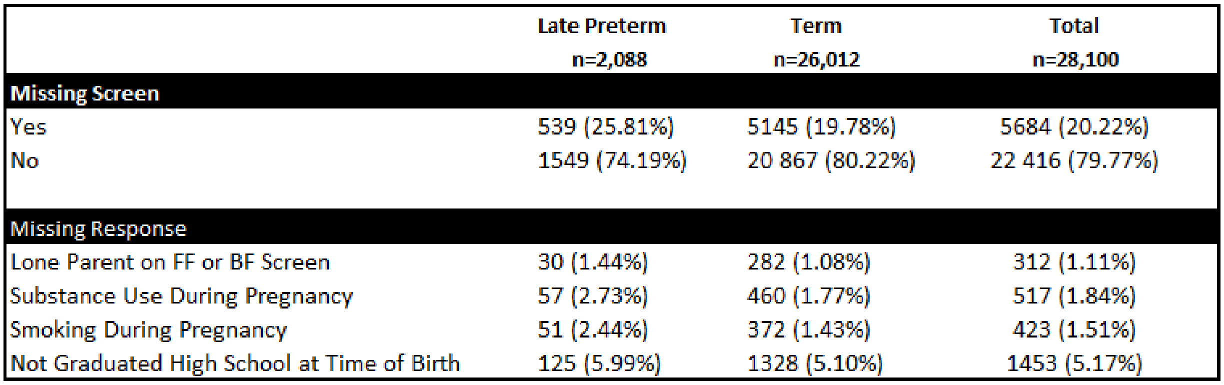


|  |  |  | Gestational Age (weeks) |  |  |
|---|---|---|---|---|---|
|  |  | Total | **34 - 36** | **39 - 41** |  |
|  | N | 28100 | 2088 | 26012 |  |
| **Family Characteristics** |  | Count (%) | Count (%) | Count (%) | p-value |
| Family size (4+) at age 4 | Yes | 2357 (8.39) | 244 (11.69) | 2113 (8.12) | <.0001 |
|  | No | 25743 (91.61) | 1844 (88.31) | 23899 (91.88) |  |
| Family size(4+) at age 7 | Yes | 3059 (10.89) | 258 (12.36) | 2801 (10.77) | 0.03 |
|  | No | 25041 (89.11) | 1830 (87.64) | 23211 (89.23) |  |
| Child in Care at any time up to 8th birthday | Yes | 1373 (4.89) | 187 (8.96) | 1186 (4.56) | <.0001 |
|  | No | 26727 (95.11) | 1901 (91.04) | 24826 (95.44) |  |
| Child in Protective Services at any time up to 8th birthday | Yes | 4649 (16.54) | 473 (22.65) | 4176 (16.05) | <.0001 |
|  | No | 23451 (83.46) | 1615 (77.35) | 21836 (83.95) |  |
| Income Assistance (at age 4) | Yes | 3220 (11.40) | 279 (13.36) | 2923 (11.24) | <.01 |
|  | No | 24898 (88.60) | 1809 (86.64) | 23089 (88.76) |  |
| Income Assistance (at age 7) | Yes | 2585 (9.20) | 236 (11.30) | 2349 (9.03) | <.001 |
|  | No | 25515 (90.80) | 1852 (88.70) | 23663 (90.97) |  |
| Income Quintile | NF | 113 (0.40) | 30 (1.44) | 83 (0.32) | <.0001 |
|  | Q1 | 4966 (17.67) | 407 (19.49) | 4559 (17.53) |  |
|  | Q2 | 5325 (18.95) | 407 (19.49) | 4918 (18.91) |  |
|  | Q3 | 5520 (19.64) | 399 (19.11) | 5121 (19.69) |  |
|  | Q4 | 5840 (20.78) | 432 (20.69) | 5408 (20.79) |  |
|  | Q5 | 6336 (22.55) | 413 (19.78) | 5923 (22.77) |  |
| Lone Parent on FF or BF Screen* | Yes | 2422 (10.93) | 185 (12.13) | 2237 (10.84) | 0.12 |
|  | No | 19742 (89.07) | 1340 (87.87) | 18402 (89.16) |  |

**Note: Based on BF/FF sub-sample*

**Comparison of FF Sample to study sample.** Similar to analyses conducted by Heaman et al. (2012), analyses were also run with the inclusion of a fourth set of social variables, those obtained from the BF/FF screen. Table 4 demonstrates that 20.12% of the entire study sample were missing a BF or FF screen. By GA, 25.81% (n=539) of the late preterm population were missing a screen compared to 19.78% % (n=5145) of the term population. In addition to those missing a screen, some mother-baby pairs with a screen were missing responses on particular screen items. For these cases, items with missing responses were entered as a categorical value of "missing" in the logistic regression modeling, so as to not exclude those who had responses to some items, but not others.

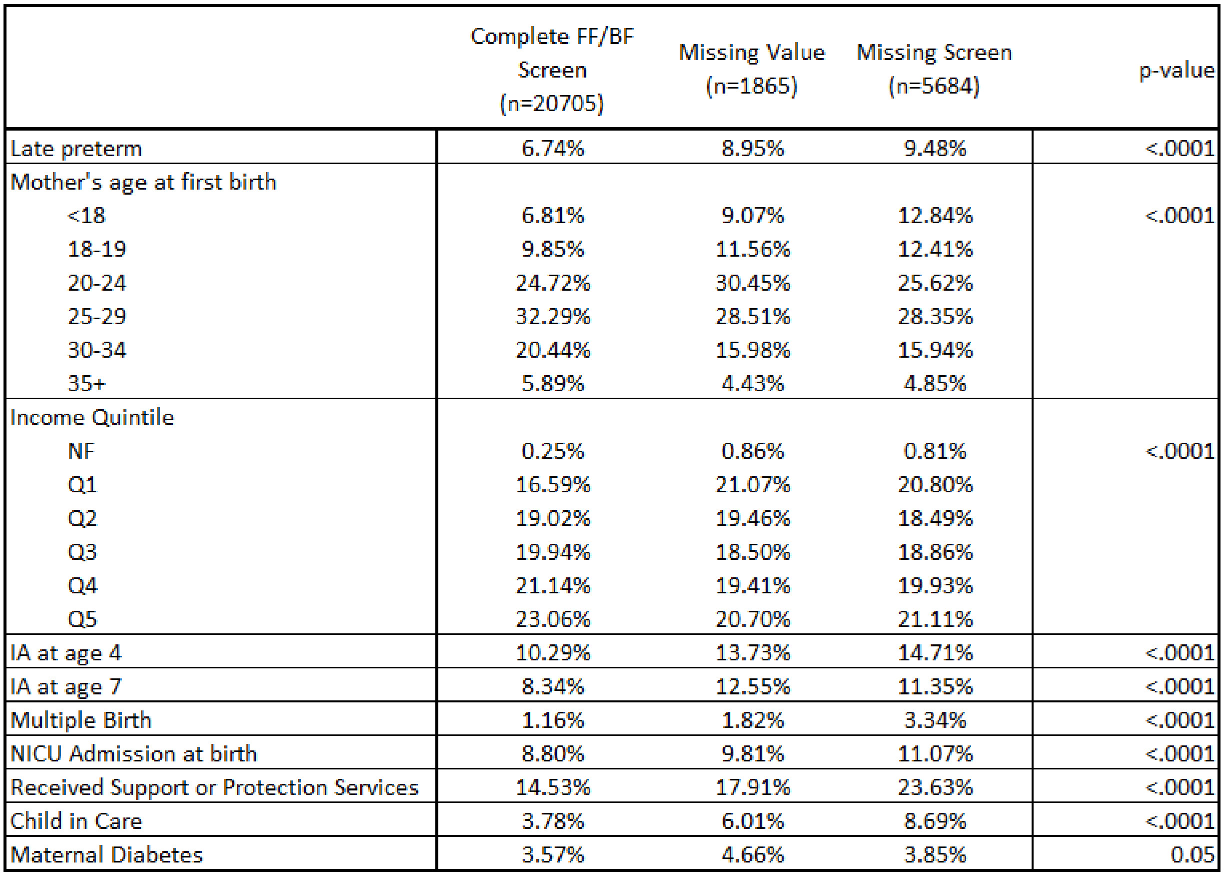
*Table 4: Missing BF/FF Response or Screen for Children born Late Preterm (34-36 weeks GA) and Term (39-41 weeks GA)*



| | Late Preterm<br>n=2,088 | Term<br>n=26,012 | Total<br>n=28,100 |
|---|---|---|---|
| **Missing Screen** | | | |
| Yes | 539 (25.81%) | 5145 (19.78%) | 5684 (20.22%) |
| No | 1549 (74.19%) | 20 867 (80.22%) | 22 416 (79.77%) |
| Missing Response | | | |
| Lone Parent on FF or BF Screen | 30 (1.44%) | 282 (1.08%) | 312 (1.11%) |
| Substance Use During Pregnancy | 57 (2.73%) | 460 (1.77%) | 517 (1.84%) |
| Smoking During Pregnancy | 51 (2.44%) | 372 (1.43%) | 423 (1.51%) |
| Not Graduated High School at Time of Birth | 125 (5.99%) | 1328 (5.10%) | 1453 (5.17%) |

Table 5 compares all infants in the study population with a fully completed screen to those who had a screen but were missing some responses on the screen, and those who had no screen. Those with missing screens or responses were more likely born late preterm, were more likely to have younger mothers at the time of first birth, be from lower income quintiles or receiving income assistance, or have an NICU admission at birth. Furthermore, those missing screen values or missing the screen were 1.23 and 1.63 times more likely to receive support and protection services and 1.59 and 2.30 times more likely to be children who were placed into care with Child and Family Services at some point before their 8th birthday. These results are indicative that within this population, those not being reached by the FF program were a more vulnerable group.

*Table 5: Characteristics of those screened verses those with missing BF/FF screen or response*



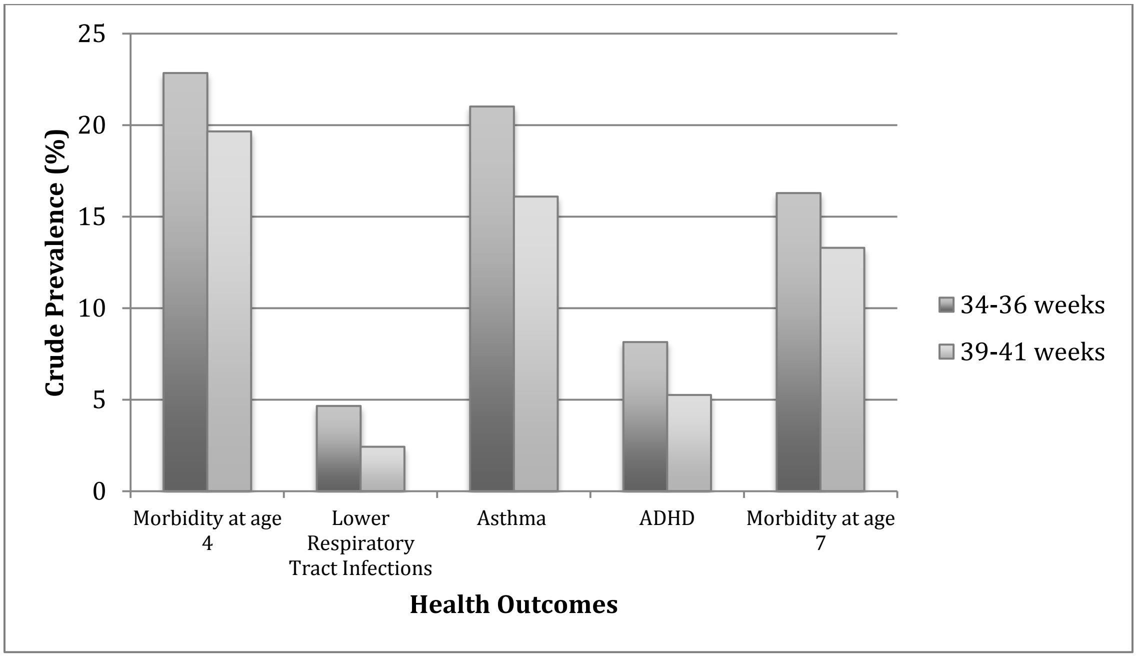
| | Complete FF/BF Screen (n=20705) | Missing Value (n=1865) | Missing Screen (n=5684) | p-value |
|---|---|---|---|---|
| Late preterm | 6.74% | 8.95% | 9.48% | <.0001 |
| Mother's age at first birth | | | | |
| <18 | 6.81% | 9.07% | 12.84% | <.0001 |
| 18-19 | 9.85% | 11.56% | 12.41% | |
| 20-24 | 24.72% | 30.45% | 25.62% | |
| 25-29 | 32.29% | 28.51% | 28.35% | |
| 30-34 | 20.44% | 15.98% | 15.94% | |
| 35+ | 5.89% | 4.43% | 4.85% | |
| Income Quintile | | | | |
| NF | 0.25% | 0.86% | 0.81% | <.0001 |
| Q1 | 16.59% | 21.07% | 20.80% | |
| Q2 | 19.02% | 19.46% | 18.49% | |
| Q3 | 19.94% | 18.50% | 18.86% | |
| Q4 | 21.14% | 19.41% | 19.93% | |
| Q5 | 23.06% | 20.70% | 21.11% | |
| IA at age 4 | 10.29% | 13.73% | 14.71% | <.0001 |
| IA at age 7 | 8.34% | 12.55% | 11.35% | <.0001 |
| Multiple Birth | 1.16% | 1.82% | 3.34% | <.0001 |
| NICU Admission at birth | 8.80% | 9.81% | 11.07% | <.0001 |
| Received Support or Protection Services | 14.53% | 17.91% | 23.63% | <.0001 |
| Child in Care | 3.78% | 6.01% | 8.69% | <.0001 |
| Maternal Diabetes | 3.57% | 4.66% | 3.85% | 0.05 |

## 4.4 Prevalence of outcomes of interest.

To examine the development of children born late preterm and at term, a number of health, educational and neurodevelopmental outcomes of interest were chosen. Figures 2 to 4 below demonstrate the crude prevalence of these outcomes by GA grouping.

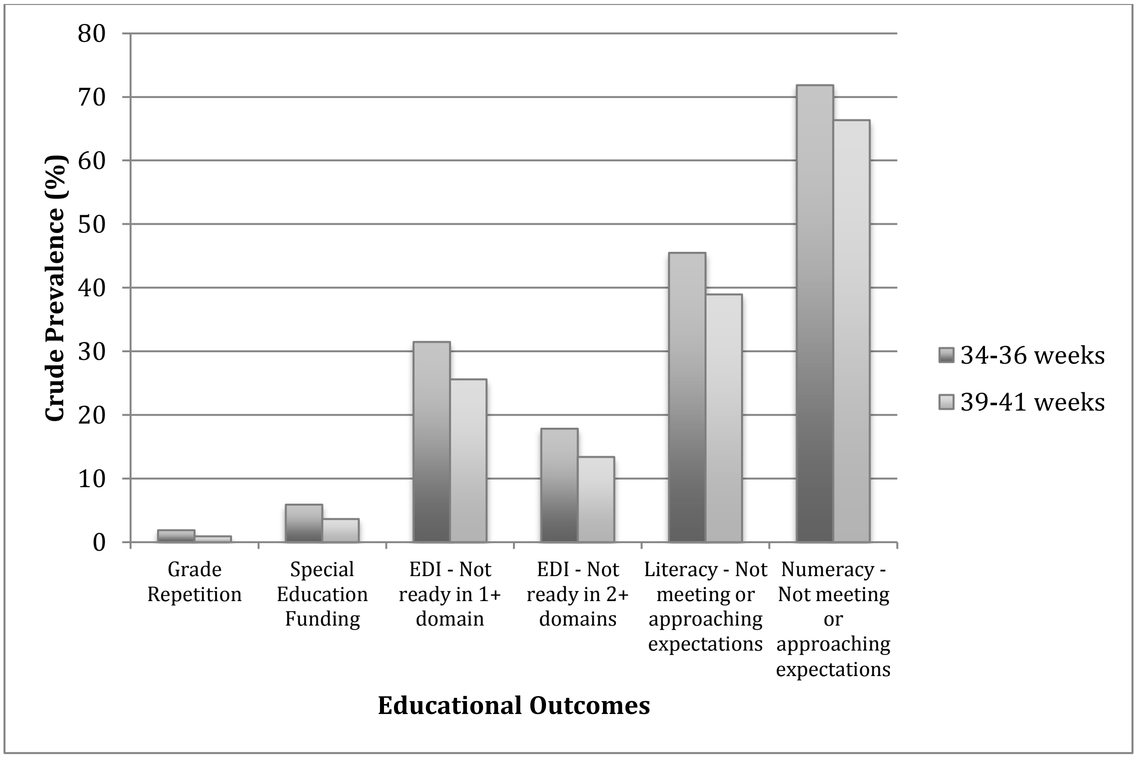
**Health Outcomes.** Measured from 1 to less than 5 years of age, the prevalence of lower respiratory tract infections was found to be statistically significantly different between the two groups (p<.0001), with a prevalence of 2.42% among those born at term and 4.65% among those born late preterm (Figure 2). The Johns Hopkins ACG® Case-Mix System’s RUB categories were used as a measure of morbidity and health services resource usage at ages 4 and 7, and demonstrated statistically significantly higher resource utilization among late preterm children at both points throughout early childhood. Health services resource utilization was found to decline as children aged, at 22.84 vs. 19.56% for late preterm and term respectively (p=0.0003) at age 4 to 16.28 vs. 13.29% (p=0.0001) at age 7. Measured from ages 6 to 8, the prevalence of asthma was statistically significantly higher (p<.0001) among children born late preterm at 21.01% compared to 16.09% among those born at term. Similarly, ADHD diagnoses were statistically significantly higher (8.14 vs. 5.25%, p<.0001) in the late preterm than the term population.

*Figure 2: Crude Prevalence of Health Outcomes by GA grouping*



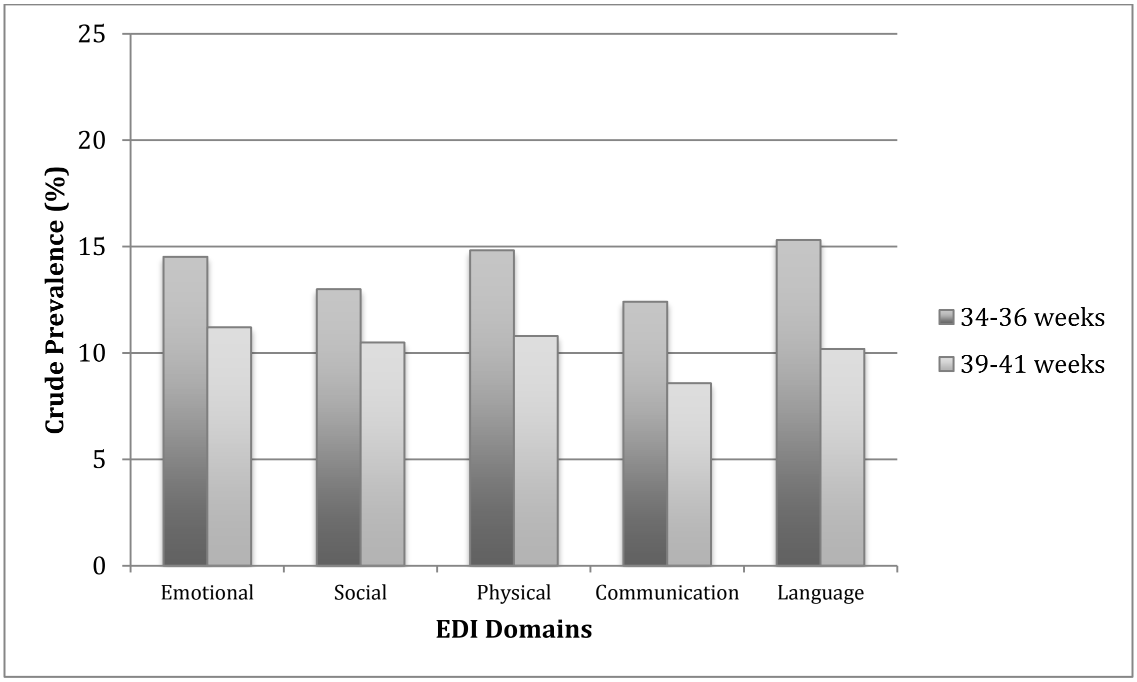
**Educational Outcomes.** The two groups were statistically significantly different (p<.0001) on all educational or developmental outcomes examined (Figure 3). Although the number of children who repeated kindergarten or grade 1 was low overall, the percentage of children repeating a grade was more than two times higher among children born late preterm (1.87%) than it was among those born at term (0.91%). Receipt of level II and III special education funding was higher in the late preterm population (5.89% vs 3.63%). The percentage of students who were not meeting expectations in grade 3 reading competency (i.e., those classified as not meeting or approaching) was higher in the late preterm population at 45.48% compared to 38.94% in the term population. Likewise, there were a larger percentage of children not meeting or approaching expectations in all 4 numeracy competencies in the late preterm population (71.84%) compared to the term population (66.34%).

*Figure 3: Crude Prevalence of Educational Outcomes by GA grouping*



As shown in Figure 4, children born late preterm were significantly more likely to not be developmentally ready to enter school in all five domains. The prevalence of being 'not ready' varied by domain. The late preterm population was most likely to be not ready in the language and cognitive development of development (15.30% vs 10.19, p<.0001). The late preterm population were also more likely to be not ready in the physical health and well-being domain of development (14.82% vs 10.79%, p<.0001), the emotional domain of development (14.52% vs 11.20%, p=0.0005), the social domain of development (12.99% vs 10.49%, p<.01), and the communication and general knowledge domain of development (12.41% vs 8.57%, p<.0001). In addition, the late preterm group was more likely to be not ready in 1 or more (31.47% vs 25.59%) and 2 or more (17.83% vs 13.39%) EDI domains (figure 3) than those born at term (p<.0001).

*Figure 4: Crude Prevalence of 'not-ready' by EDI domain by GA grouping*



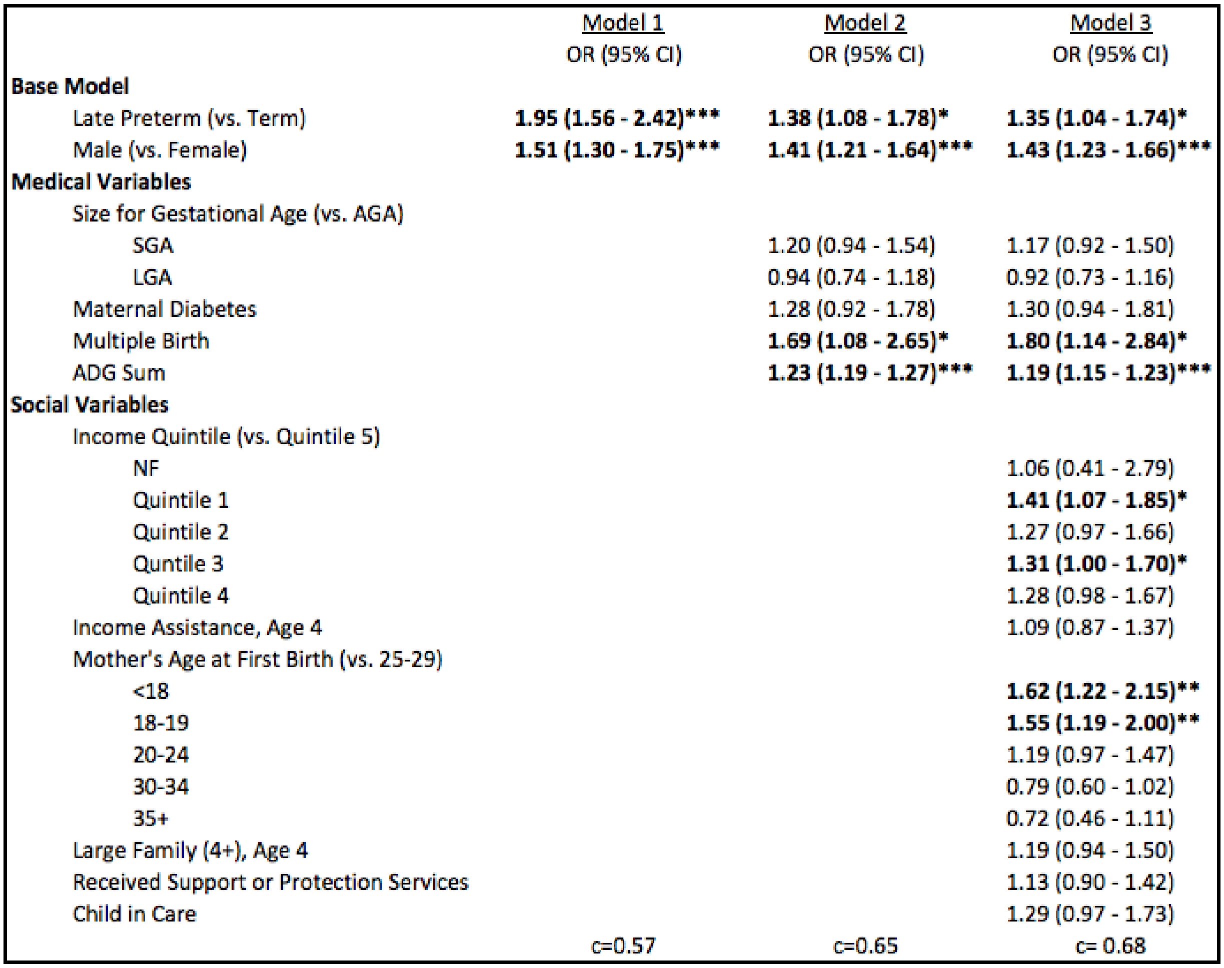
## 4.5 Regression Models

The variables included in modeling have been described previously (see chapter 3). Variables were introduced into the models in three steps: (1) base variables, (2) medical variables, and (3) social variables, in order to examine the relative contribution of social and biological impacts on the outcomes of interest. Each model is then presented a second time (see appendix B) with the addition of a fourth step, which includes the BF/FF variables. These latter models were run only on those who received a BF/FF screen, and thus, constitute a smaller, and less representative population.

## Health Outcomes

***Lower Respiratory Tract Infections.*** Table 6 presents the results of the multiple logistic regression analysis that examined the relationship between an occurrence of a lower respiratory tract infection (LRTI) at any point between 1 and 5 years of age and GA. Model 1 shows the base or sex-adjusted model, demonstrating that after controlling for sex, the odds of having an LRTI were 1.95 times higher in the late preterm group compared to those born at term (p<.0001). Additionally, the odds of LRTI diagnoses were 1.51 times higher among males than females (<.0001). Model 2 demonstrates that prematurity remains significant after introducing medical factors, and that being part of a multiple birth, having a high number of diagnoses during the first year of life and being a male are all significantly associated with the odds of having an LRTI in the early childhood period. Model 3 revealed significant associations between LTRIs and several medical and social variables. Among medical predictors, multiple birth (OR=1.80) and poor health status during the first year of life (OR=1.23) remained significant. Living in a low or middle income area was associated with LRTI diagnoses, as the odds of LRTIs were 1.41 and 1.31 times higher in income quintiles 1 and 3 compared to income quintile 5 (p<.05). Additionally, the odds were higher among children whose mothers were young (<18 and 18-19) at the time of their first birth (p<.01), showing elevated odds of an LRTI by 1.62 and 1.55 respectively. Prematurity remained significant at the p<.05 level and suggested that after controlling for a number of variables, the odds of having an LRTI were 1.35 times higher among children born late preterm. All other variables demonstrated no significant associations in the models.

*Table 6: Logistic Regression Models of Lower Respiratory Tract Infections (n=28,100)*

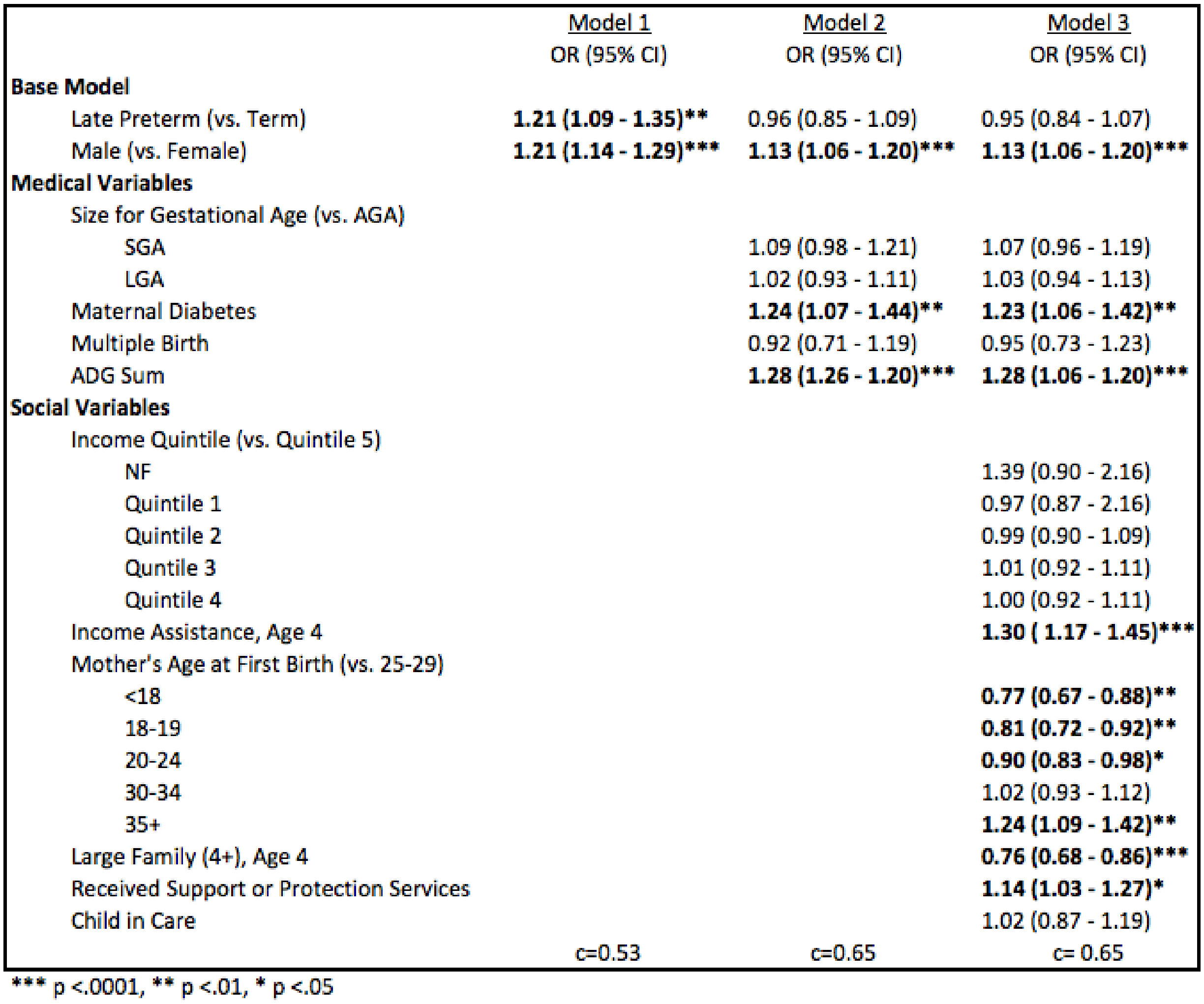


| | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| | OR (95% CI) | OR (95% CI) | OR (95% CI) |
| **Base Model** | | | |
| Late Preterm (vs. Term) | **1.95 (1.56 - 2.42)*** ** | **1.38 (1.08 - 1.78)*** | **1.35 (1.04 - 1.74)*** |
| Male (vs. Female) | **1.51 (1.30 - 1.75)*** ** | **1.41 (1.21 - 1.64)*** ** | **1.43 (1.23 - 1.66)*** ** |
| **Medical Variables** | | | |
| Size for Gestational Age (vs. AGA) | | | |
| SGA | | 1.20 (0.94 - 1.54) | 1.17 (0.92 - 1.50) |
| LGA | | 0.94 (0.74 - 1.18) | 0.92 (0.73 - 1.16) |
| Maternal Diabetes | | 1.28 (0.92 - 1.78) | 1.30 (0.94 - 1.81) |
| Multiple Birth | | **1.69 (1.08 - 2.65)*** | **1.80 (1.14 - 2.84)*** |
| ADG Sum | | **1.23 (1.19 - 1.27)*** ** | **1.19 (1.15 - 1.23)*** ** |
| **Social Variables** | | | |
| Income Quintile (vs. Quintile 5) | | | |
| NF | | | 1.06 (0.41 - 2.79) |
| Quintile 1 | | | **1.41 (1.07 - 1.85)*** |
| Quintile 2 | | | 1.27 (0.97 - 1.66) |
| Quntile 3 | | | **1.31 (1.00 - 1.70)*** |
| Quintile 4 | | | 1.28 (0.98 - 1.67) |
| Income Assistance, Age 4 | | | 1.09 (0.87 - 1.37) |
| Mother's Age at First Birth (vs. 25-29) | | | |
| <18 | | | **1.62 (1.22 - 2.15)** ** |
| 18-19 | | | **1.55 (1.19 - 2.00)** ** |
| 20-24 | | | 1.19 (0.97 - 1.47) |
| 30-34 | | | 0.79 (0.60 - 1.02) |
| 35+ | | | 0.72 (0.46 - 1.11) |
| Large Family (4+), Age 4 | | | 1.19 (0.94 - 1.50) |
| Received Support or Protection Services | | | 1.13 (0.90 - 1.42) |
| Child in Care | | | 1.29 (0.97 - 1.73) |
| | c=0.57 | c=0.65 | c= 0.68 |

*** p <.0001, ** p <.01, * p <.05

***Morbidity at age 4.*** Morbidity was calculated using the simplified Johns Hopkins resource utilization band (RUB) ranking system for each child between the ages of 3 and 4. Because the frequency of high and very high morbidity was low, morbidity was coded as 1 if the child scored a RUB value between 3 and 5, which indicated moderate to very high morbidity. Table 7 demonstrates that although prematurity was significant in the sex adjusted (base) model, the effect disappeared once medical and social factors were considered. Model 3 demonstrates that maternal diabetes (OR=1.23), poor health status during the first year of life (OR=1.28), family receipt of income assistance at age 4 (OR=1.30), receiving support or protection services from child and family services (OR=1.14) and high maternal age at first birth (35+, OR=1.30) were all significantly associated with morbidity at age 4. Being part of a large family (OR=0.76) and a maternal age at first birth younger than 25 were associated with lower odds of morbidity at age 4. The odds of morbidity at age 4 were 13% higher among males in models 2 and 3 (p<.0003).

*Table 7: Logistic Regression Models of morbidity at age 4 (n=28,100)*

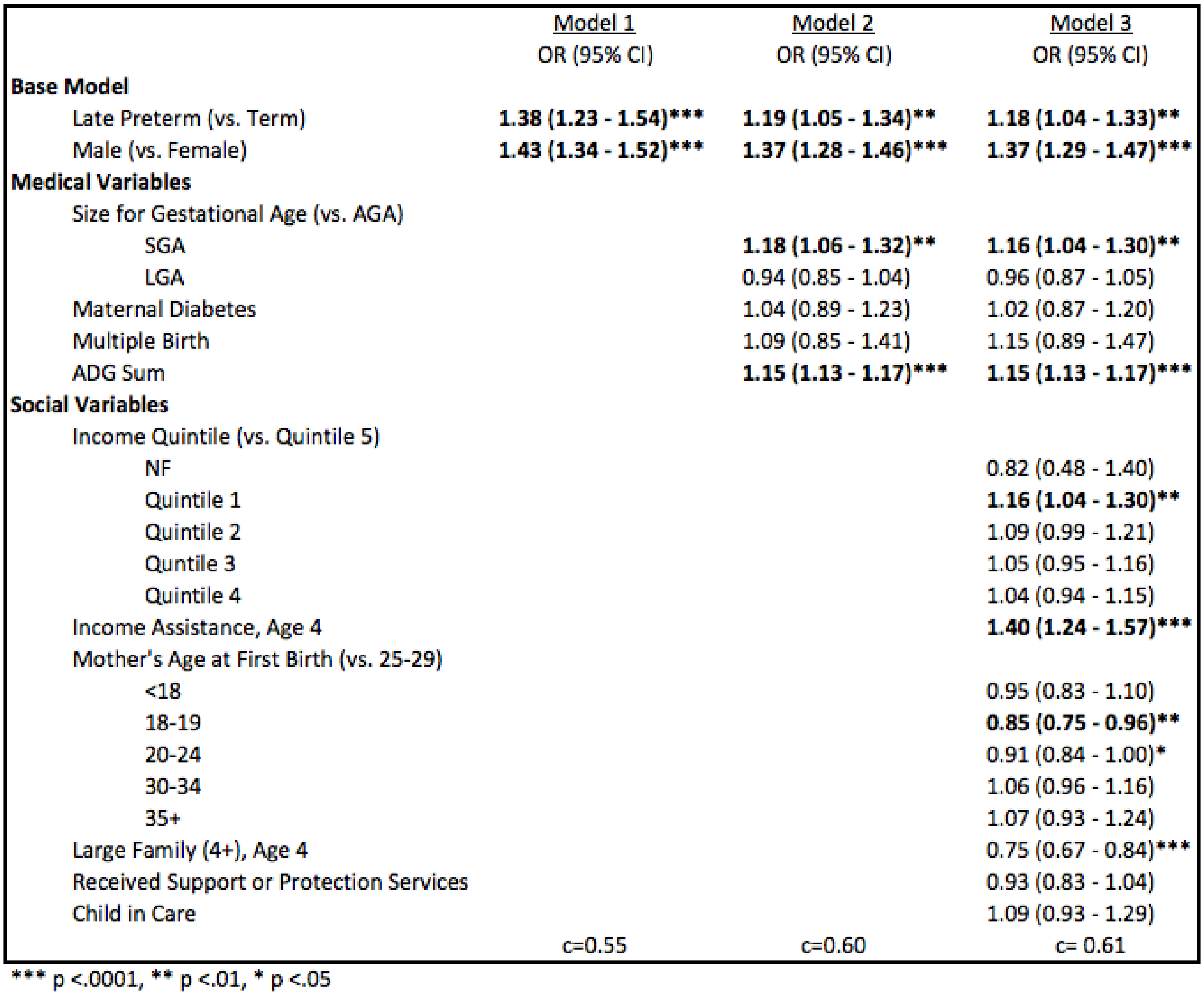


| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) |
|---|---|---|---|
| **Base Model** | | | |
| Late Preterm (vs. Term) | **1.21 (1.09 - 1.35)**** | 0.96 (0.85 - 1.09) | 0.95 (0.84 - 1.07) |
| Male (vs. Female) | **1.21 (1.14 - 1.29)***** | **1.13 (1.06 - 1.20)***** | **1.13 (1.06 - 1.20)***** |
| **Medical Variables** | | | |
| Size for Gestational Age (vs. AGA) | | | |
| SGA | | 1.09 (0.98 - 1.21) | 1.07 (0.96 - 1.19) |
| LGA | | 1.02 (0.93 - 1.11) | 1.03 (0.94 - 1.13) |
| Maternal Diabetes | | **1.24 (1.07 - 1.44)**** | **1.23 (1.06 - 1.42)**** |
| Multiple Birth | | 0.92 (0.71 - 1.19) | 0.95 (0.73 - 1.23) |
| ADG Sum | | **1.28 (1.26 - 1.20)***** | **1.28 (1.06 - 1.20)***** |
| **Social Variables** | | | |
| Income Quintile (vs. Quintile 5) | | | |
| NF | | | 1.39 (0.90 - 2.16) |
| Quintile 1 | | | 0.97 (0.87 - 2.16) |
| Quintile 2 | | | 0.99 (0.90 - 1.09) |
| Quntile 3 | | | 1.01 (0.92 - 1.11) |
| Quintile 4 | | | 1.00 (0.92 - 1.11) |
| Income Assistance, Age 4 | | | **1.30 ( 1.17 - 1.45)***** |
| Mother's Age at First Birth (vs. 25-29) | | | |
| <18 | | | **0.77 (0.67 - 0.88)**** |
| 18-19 | | | **0.81 (0.72 - 0.92)**** |
| 20-24 | | | **0.90 (0.83 - 0.98)*** |
| 30-34 | | | 1.02 (0.93 - 1.12) |
| 35+ | | | **1.24 (1.09 - 1.42)**** |
| Large Family (4+), Age 4 | | | **0.76 (0.68 - 0.86)***** |
| Received Support or Protection Services | | | **1.14 (1.03 - 1.27)*** |
| Child in Care | | | 1.02 (0.87 - 1.19) |
| | c=0.53 | c=0.65 | c= 0.65 |

*** p <.0001, ** p <.01, * p <.05

***Asthma.*** Table 8 demonstrates that for the base model, children born late preterm had 38% higher odds of having an asthma diagnosis between the ages of 6 to 8 and that males had increased odds of asthma diagnosis. In models 2 and 3, the effect of prematurity remained significant with medical and social factors included. Additional predictors of an asthma diagnosis included being born SGA (OR=1.16), poor health status during the first year of life (OR=1.15), family receipt of income assistance at age 7 (OR=1.40), and being from income quintile 1 (OR=1.16). A maternal age at first birth of 18-19 was associated with a 15% reduced odds of asthma diagnosis compared to a maternal age at first birth of 25-29.

*Table 8: Logistic Regression models of Asthma at ages 6 to 8 (n=28,100)*



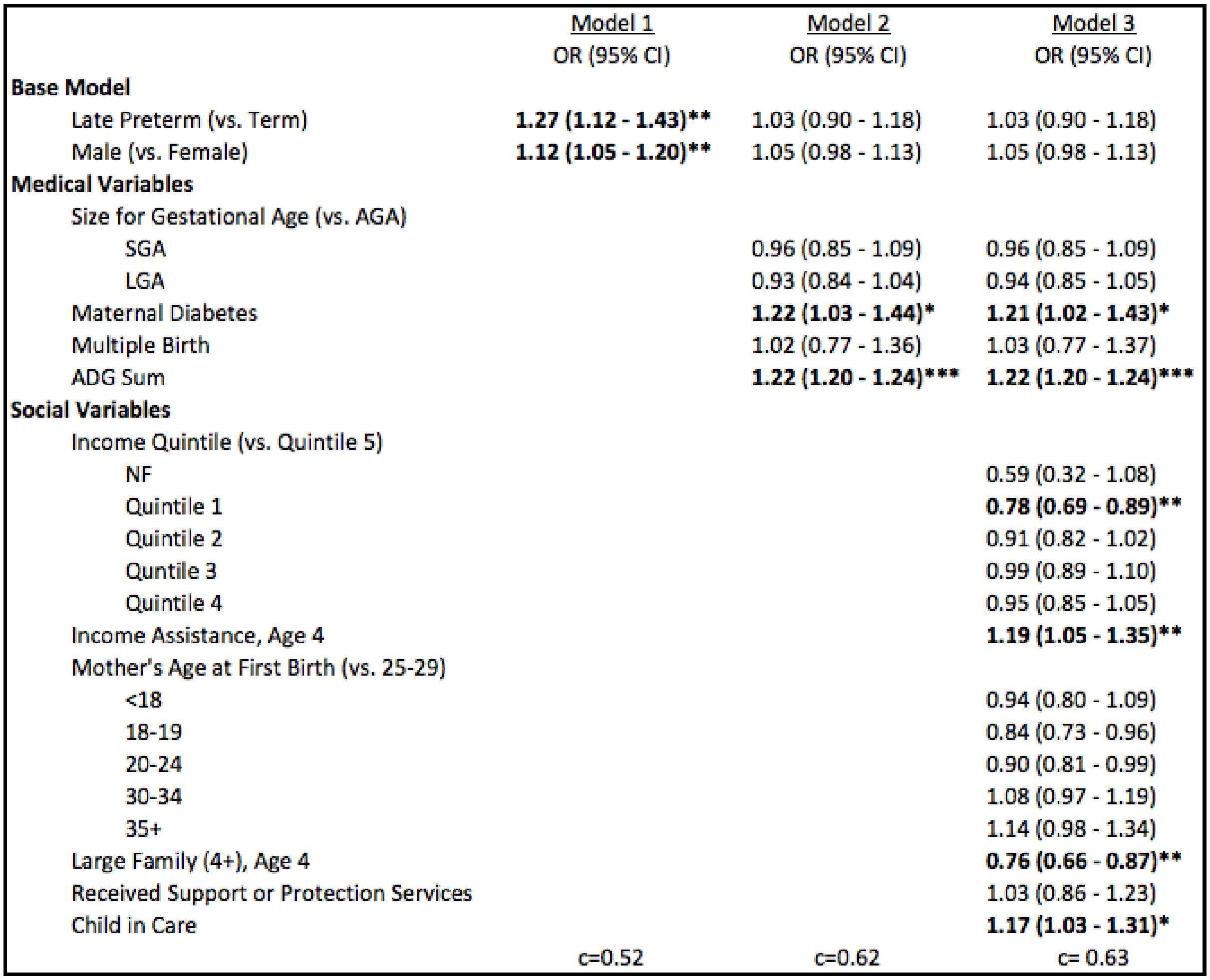
| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) |
|---|---|---|---|
| **Base Model** | | | |
| Late Preterm (vs. Term) | **1.38 (1.23 - 1.54)***** | **1.19 (1.05 - 1.34)**** | **1.18 (1.04 - 1.33)**** |
| Male (vs. Female) | **1.43 (1.34 - 1.52)***** | **1.37 (1.28 - 1.46)***** | **1.37 (1.29 - 1.47)***** |
| **Medical Variables** | | | |
| Size for Gestational Age (vs. AGA) | | | |
| SGA | | **1.18 (1.06 - 1.32)**** | **1.16 (1.04 - 1.30)**** |
| LGA | | 0.94 (0.85 - 1.04) | 0.96 (0.87 - 1.05) |
| Maternal Diabetes | | 1.04 (0.89 - 1.23) | 1.02 (0.87 - 1.20) |
| Multiple Birth | | 1.09 (0.85 - 1.41) | 1.15 (0.89 - 1.47) |
| ADG Sum | | **1.15 (1.13 - 1.17)***** | **1.15 (1.13 - 1.17)***** |
| **Social Variables** | | | |
| Income Quintile (vs. Quintile 5) | | | |
| NF | | | 0.82 (0.48 - 1.40) |
| Quintile 1 | | | **1.16 (1.04 - 1.30)**** |
| Quintile 2 | | | 1.09 (0.99 - 1.21) |
| Quntile 3 | | | 1.05 (0.95 - 1.16) |
| Quintile 4 | | | 1.04 (0.94 - 1.15) |
| Income Assistance, Age 4 | | | **1.40 (1.24 - 1.57)***** |
| Mother's Age at First Birth (vs. 25-29) | | | |
| <18 | | | 0.95 (0.83 - 1.10) |
| 18-19 | | | **0.85 (0.75 - 0.96)**** |
| 20-24 | | | 0.91 (0.84 - 1.00)* |
| 30-34 | | | 1.06 (0.96 - 1.16) |
| 35+ | | | 1.07 (0.93 - 1.24) |
| Large Family (4+), Age 4 | | | 0.75 (0.67 - 0.84)*** |
| Received Support or Protection Services | | | 0.93 (0.83 - 1.04) |
| Child in Care | | | 1.09 (0.93 - 1.29) |
| | c=0.55 | c=0.60 | c= 0.61 |

*** p <.0001, ** p <.01, * p <.05

***Morbidity at age 7.*** As seen in table 9, though the late preterm group had significantly higher odds of morbidity at age 7 in model 1 (OR=1.27, p<.01), models 2 and 3 suggest that other factors are more influential in determining morbidity at age 7 than GA. Based on model 3, maternal diabetes and poor health during the first year of life increased the odds of morbidity

1.21 (p<.05) and 1.22 (p<.0001) times. Family receipt of income assistance and being a child in care were also predictive of morbidity at age 7, and were associated with increased odds of 1.19 (p<.01) and 1.17 (p<.05) times, respectively. High morbidity or health care utilization appears to occur more so in the higher income quintiles, and those in quintile 1 were found to have 22% lower odds of having moderate to high morbidity (p<.01). Furthermore, being in a family with 4 or more children was found to be associated with 24% lower odds of higher morbidity than being in a family with fewer children (p<.01).

*Table 9: Logistic Regression Models of Morbidity at age 7 (n=28,100)*

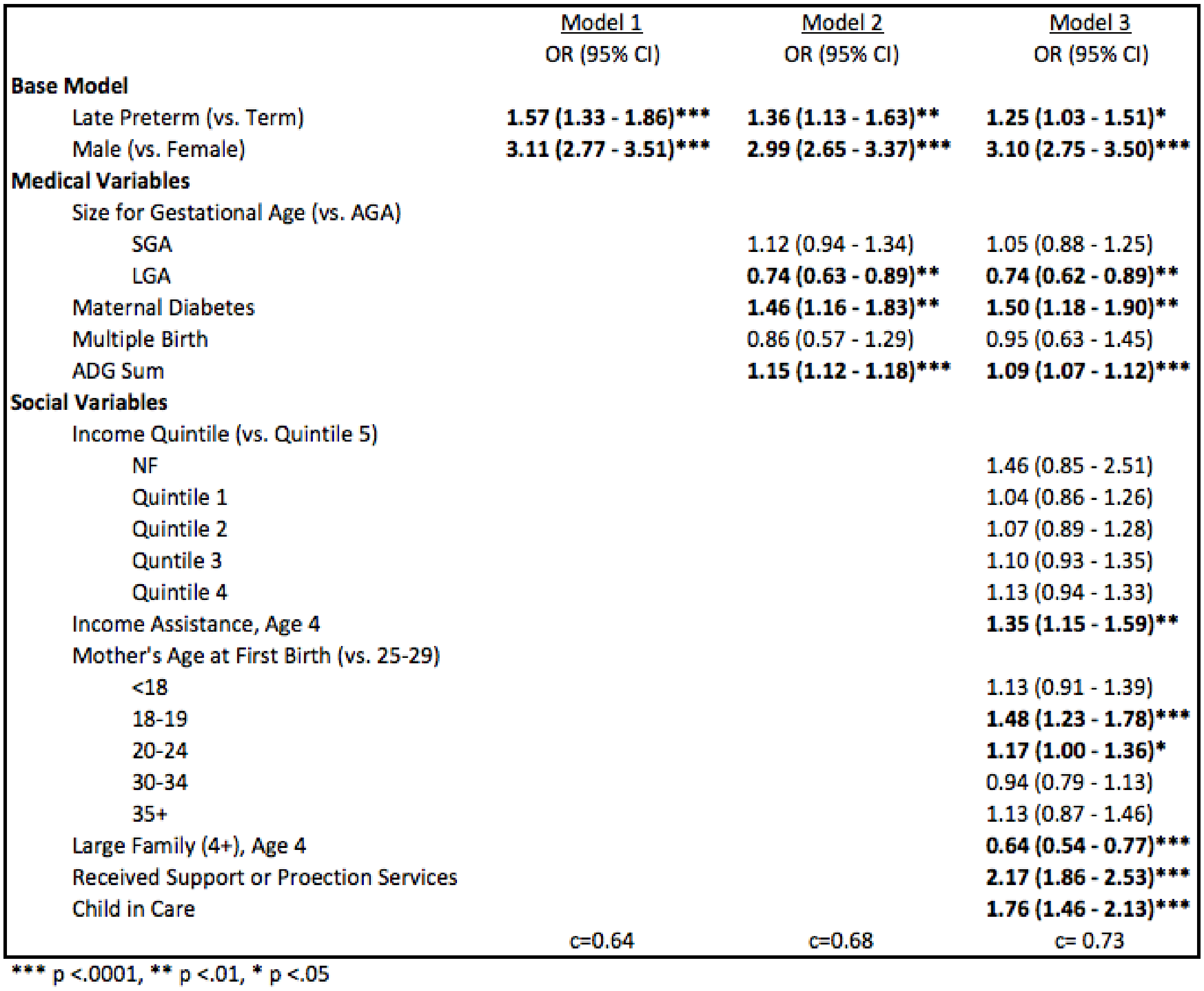


| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) |
|---|---|---|---|
| **Base Model** | | | |
| Late Preterm (vs. Term) | **1.27 (1.12 - 1.43)**** | 1.03 (0.90 - 1.18) | 1.03 (0.90 - 1.18) |
| Male (vs. Female) | **1.12 (1.05 - 1.20)**** | 1.05 (0.98 - 1.13) | 1.05 (0.98 - 1.13) |
| **Medical Variables** | | | |
| Size for Gestational Age (vs. AGA) | | | |
| SGA | | 0.96 (0.85 - 1.09) | 0.96 (0.85 - 1.09) |
| LGA | | 0.93 (0.84 - 1.04) | 0.94 (0.85 - 1.05) |
| Maternal Diabetes | | **1.22 (1.03 - 1.44)*** | **1.21 (1.02 - 1.43)*** |
| Multiple Birth | | 1.02 (0.77 - 1.36) | 1.03 (0.77 - 1.37) |
| ADG Sum | | **1.22 (1.20 - 1.24)***** | **1.22 (1.20 - 1.24)***** |
| **Social Variables** | | | |
| Income Quintile (vs. Quintile 5) | | | |
| NF | | | 0.59 (0.32 - 1.08) |
| Quintile 1 | | | **0.78 (0.69 - 0.89)**** |
| Quintile 2 | | | 0.91 (0.82 - 1.02) |
| Quntile 3 | | | 0.99 (0.89 - 1.10) |
| Quintile 4 | | | 0.95 (0.85 - 1.05) |
| Income Assistance, Age 4 | | | **1.19 (1.05 - 1.35)**** |
| Mother's Age at First Birth (vs. 25-29) | | | |
| <18 | | | 0.94 (0.80 - 1.09) |
| 18-19 | | | 0.84 (0.73 - 0.96) |
| 20-24 | | | 0.90 (0.81 - 0.99) |
| 30-34 | | | 1.08 (0.97 - 1.19) |
| 35+ | | | 1.14 (0.98 - 1.34) |
| Large Family (4+), Age 4 | | | **0.76 (0.66 - 0.87)**** |
| Received Support or Protection Services | | | 1.03 (0.86 - 1.23) |
| Child in Care | | | **1.17 (1.03 - 1.31)*** |
| | c=0.52 | c=0.62 | c= 0.63 |

*** p <.0001, ** p <.01, * p <.05

***ADHD.*** Though the odds of receiving an ADHD diagnosis between ages 5 and 8 reduced by 19 and 11% with the inclusion of medical and social factors, the late preterm population still had 1.25 times higher odds of having had an ADHD diagnosis than those born at term (p<.05). Several variables were significant in model 3 at the p<.0001 level including male sex (OR=3.10), a maternal age at first birth of 18-19 (OR=1.48), poor health status during the first year of life (OR=1.09), and children whose families received support or protection services (OR=2.17) or were placed in care with CFS (OR=1.76) at any point before the child's 8th birthday. Additional factors associated with ADHD diagnosis in model 3 included children whose mothers had maternal diabetes (OR=1.50, p<.01), receipt of income assistance at age 4 (OR= 1.35, p<.01), and a maternal age at first birth between 20 and 24 years of age (OR=1.17, p<.05). Former LGA neonates were found to have 26% lower odds of ADHD (OR=0.74, p<.01) and being part of a large family was associated with lower odds of ADHD (OR=0.64, p<.0001).

*Table 10: Logistic Regression Models of ADHD (n=28,100)*



| | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| | OR (95% CI) | OR (95% CI) | OR (95% CI) |
| **Base Model** | | | |
| Late Preterm (vs. Term) | **1.57 (1.33 - 1.86)***** | **1.36 (1.13 - 1.63)**** | **1.25 (1.03 - 1.51)*** |
| Male (vs. Female) | **3.11 (2.77 - 3.51)***** | **2.99 (2.65 - 3.37)***** | **3.10 (2.75 - 3.50)***** |
| **Medical Variables** | | | |
| Size for Gestational Age (vs. AGA) | | | |
| SGA | | 1.12 (0.94 - 1.34) | 1.05 (0.88 - 1.25) |
| LGA | | **0.74 (0.63 - 0.89)**** | **0.74 (0.62 - 0.89)**** |
| Maternal Diabetes | | **1.46 (1.16 - 1.83)**** | **1.50 (1.18 - 1.90)**** |
| Multiple Birth | | 0.86 (0.57 - 1.29) | 0.95 (0.63 - 1.45) |
| ADG Sum | | **1.15 (1.12 - 1.18)***** | **1.09 (1.07 - 1.12)***** |
| **Social Variables** | | | |
| Income Quintile (vs. Quintile 5) | | | |
| NF | | | 1.46 (0.85 - 2.51) |
| Quintile 1 | | | 1.04 (0.86 - 1.26) |
| Quintile 2 | | | 1.07 (0.89 - 1.28) |
| Quntile 3 | | | 1.10 (0.93 - 1.35) |
| Quintile 4 | | | 1.13 (0.94 - 1.33) |
| Income Assistance, Age 4 | | | **1.35 (1.15 - 1.59)**** |
| Mother's Age at First Birth (vs. 25-29) | | | |
| <18 | | | 1.13 (0.91 - 1.39) |
| 18-19 | | | **1.48 (1.23 - 1.78)***** |
| 20-24 | | | **1.17 (1.00 - 1.36)*** |
| 30-34 | | | 0.94 (0.79 - 1.13) |
| 35+ | | | 1.13 (0.87 - 1.46) |
| Large Family (4+), Age 4 | | | **0.64 (0.54 - 0.77)***** |
| Received Support or Proection Services | | | **2.17 (1.86 - 2.53)***** |
| Child in Care | | | **1.76 (1.46 - 2.13)***** |
| | c=0.64 | c=0.68 | c= 0.73 |

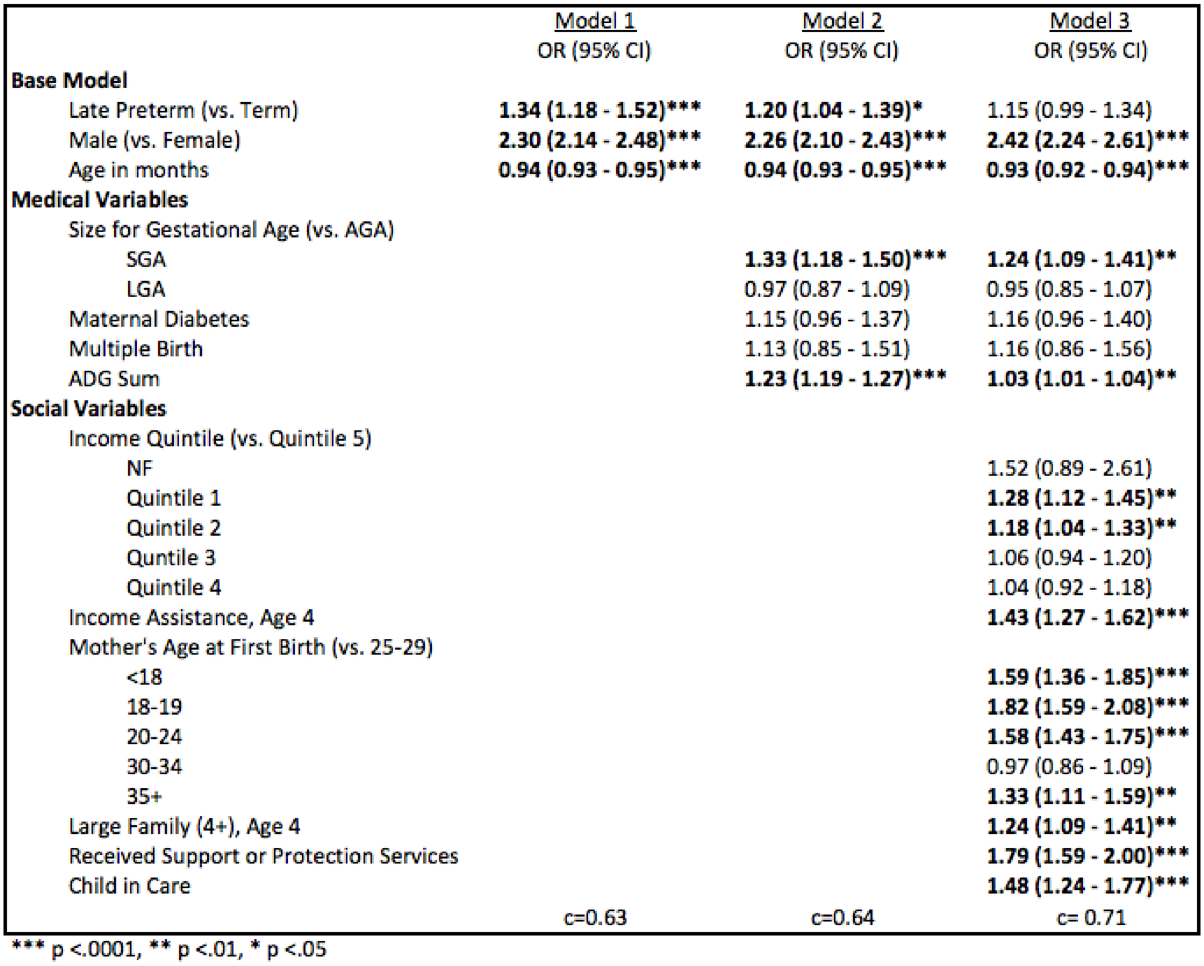
*** p <.0001, ** p <.01, * p <.05

### EDI and Education Outcomes

***Not ready in 1+ domain.*** As seen in table 11, prematurity was a significant contributor to being not ready in 1 or more EDI domains during the kindergarten year in model 1 (OR=1.34, p<.0001) and 2 (OR=1.20, p<.05), but became non-significant once social factors were considered (model 3). A number of factors were associated with school readiness. Model 3 shows that low income status, including receipt of income assistance at age 4 (OR=1.43, p<.0001) and being from income quintile 1 (OR= 1.28, p<.01) or 2 (OR= 1.18, p<.01) increased the odds of being not ready for school. Families receiving support or protection services

(OR=1.79, p<.0001) and children taken into the care of CFS (OR=1.48, p<.0001) were significantly more likely to be not ready for school, as were children from large families (OR=1.24, p<.01). A maternal age at first birth below 25 and over 35 years was more likely to be associated with increased odds of being not ready in at least one domain. Medical variables associated with not being ready to learn included being born SGA (OR=1.24, p<.01) and poorer health status during the first year of life (OR=1.23, p<.0001), although these odds decreased once social variables were included in the model (OR=1.03, p<.01). Finally, males had 2.42 times the odds of being not ready in one or more domain (p<.0001) and being older at time of assessment was found to decrease the odds of poor outcomes (OR=0.93, p<.0001).

*Table 11: Logistic Regression Models of 'not ready' in 1+ EDI domain (n=16,420)*

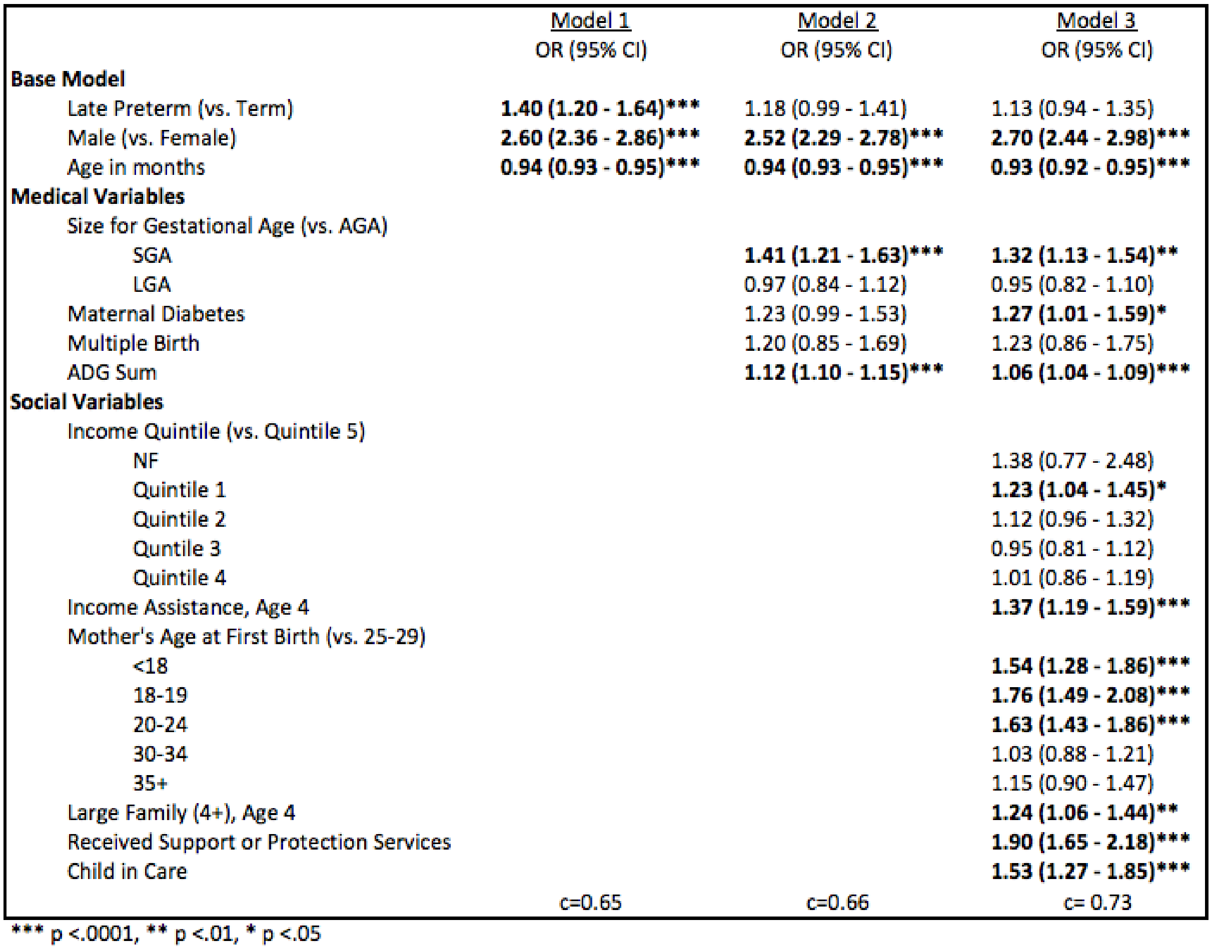


| | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| | OR (95% CI) | OR (95% CI) | OR (95% CI) |
| **Base Model** | | | |
| Late Preterm (vs. Term) | **1.34 (1.18 - 1.52)***** | **1.20 (1.04 - 1.39)*** | 1.15 (0.99 - 1.34) |
| Male (vs. Female) | **2.30 (2.14 - 2.48)***** | **2.26 (2.10 - 2.43)***** | **2.42 (2.24 - 2.61)***** |
| Age in months | **0.94 (0.93 - 0.95)***** | **0.94 (0.93 - 0.95)***** | **0.93 (0.92 - 0.94)***** |
| **Medical Variables** | | | |
| Size for Gestational Age (vs. AGA) | | | |
| SGA | | **1.33 (1.18 - 1.50)***** | **1.24 (1.09 - 1.41)**** |
| LGA | | 0.97 (0.87 - 1.09) | 0.95 (0.85 - 1.07) |
| Maternal Diabetes | | 1.15 (0.96 - 1.37) | 1.16 (0.96 - 1.40) |
| Multiple Birth | | 1.13 (0.85 - 1.51) | 1.16 (0.86 - 1.56) |
| ADG Sum | | **1.23 (1.19 - 1.27)***** | **1.03 (1.01 - 1.04)**** |
| **Social Variables** | | | |
| Income Quintile (vs. Quintile 5) | | | |
| NF | | | 1.52 (0.89 - 2.61) |
| Quintile 1 | | | **1.28 (1.12 - 1.45)**** |
| Quintile 2 | | | **1.18 (1.04 - 1.33)**** |
| Quntile 3 | | | 1.06 (0.94 - 1.20) |
| Quintile 4 | | | 1.04 (0.92 - 1.18) |
| Income Assistance, Age 4 | | | **1.43 (1.27 - 1.62)***** |
| Mother's Age at First Birth (vs. 25-29) | | | |
| <18 | | | **1.59 (1.36 - 1.85)***** |
| 18-19 | | | **1.82 (1.59 - 2.08)***** |
| 20-24 | | | **1.58 (1.43 - 1.75)***** |
| 30-34 | | | 0.97 (0.86 - 1.09) |
| 35+ | | | **1.33 (1.11 - 1.59)**** |
| Large Family (4+), Age 4 | | | **1.24 (1.09 - 1.41)**** |
| Received Support or Protection Services | | | **1.79 (1.59 - 2.00)***** |
| Child in Care | | | **1.48 (1.24 - 1.77)***** |
| | c=0.63 | c=0.64 | c= 0.71 |

*** p <.0001, ** p <.01, * p <.05

***Not ready in 2+ domains.*** Although model 1 (age- and sex-adjusted) demonstrated a 40% increase in odds of being not ready for school in 2 or more domains for children born late preterm, prematurity was not found to be a significant predictor of this outcome in models 2 and 3, once adjusted for medical and social factors. Model 3 demonstrates that the following medical variables are significant contributors to school unpreparedness on multiple domains: being born SGA (OR=1.32, p<.01), maternal diabetes (OR=1.27, p<.05), and poor health status during the first year of life (OR=1.06, p<.0001). Low income status, including those who received income assistance at age 4 (OR=1.37, p<.0001) and in income quintile 1 (OR=1.23, p<.05) had higher odds of not being ready in 2 or more domains. Being a first time mother at ages 18-19 (OR=1.76, p<.0001), 20-24 (OR=1.63, p<.0001), followed by <18 (OR=1.54, p<.0001), increased the odds by 54 to 76%. Finally, families receiving support or protection services, being a child in care, and belonging to a large family increased the odds 1.90, 1.53 and 1.24 times.

*Table 12: Logistic Regression Models of 'not ready' in 2+ EDI domains (n=16,420)*



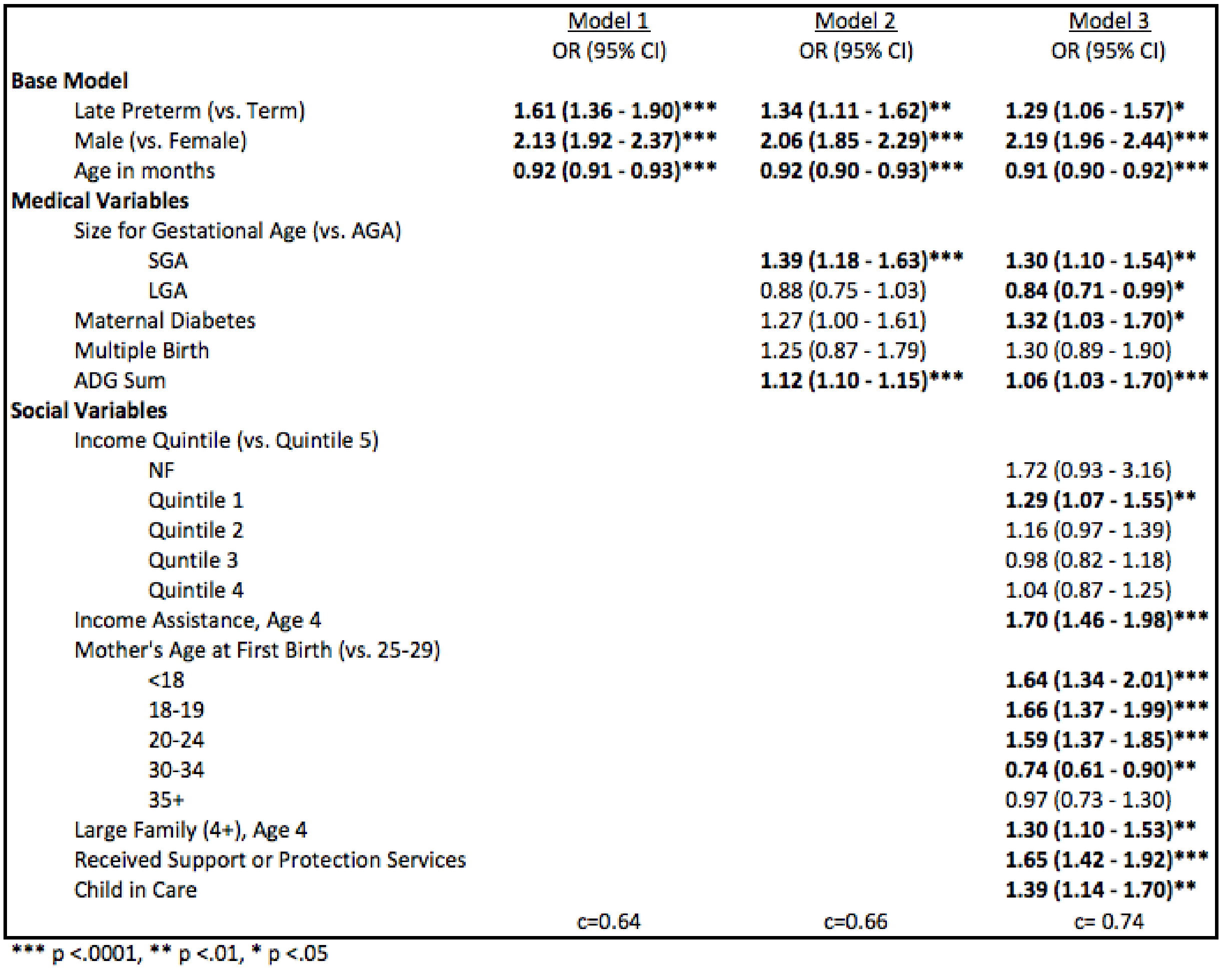
| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) |
|---|---|---|---|
| **Base Model** | | | |
| Late Preterm (vs. Term) | **1.40 (1.20 - 1.64)*** ** | 1.18 (0.99 - 1.41) | 1.13 (0.94 - 1.35) |
| Male (vs. Female) | **2.60 (2.36 - 2.86)*** ** | **2.52 (2.29 - 2.78)*** ** | **2.70 (2.44 - 2.98)*** ** |
| Age in months | **0.94 (0.93 - 0.95)*** ** | **0.94 (0.93 - 0.95)*** ** | **0.93 (0.92 - 0.95)*** ** |
| **Medical Variables** | | | |
| Size for Gestational Age (vs. AGA) | | | |
| SGA | | **1.41 (1.21 - 1.63)*** ** | **1.32 (1.13 - 1.54)** ** |
| LGA | | 0.97 (0.84 - 1.12) | 0.95 (0.82 - 1.10) |
| Maternal Diabetes | | 1.23 (0.99 - 1.53) | **1.27 (1.01 - 1.59)* ** |
| Multiple Birth | | 1.20 (0.85 - 1.69) | 1.23 (0.86 - 1.75) |
| ADG Sum | | **1.12 (1.10 - 1.15)*** ** | **1.06 (1.04 - 1.09)*** ** |
| **Social Variables** | | | |
| Income Quintile (vs. Quintile 5) | | | |
| NF | | | 1.38 (0.77 - 2.48) |
| Quintile 1 | | | **1.23 (1.04 - 1.45)* ** |
| Quintile 2 | | | 1.12 (0.96 - 1.32) |
| Quntile 3 | | | 0.95 (0.81 - 1.12) |
| Quintile 4 | | | 1.01 (0.86 - 1.19) |
| Income Assistance, Age 4 | | | **1.37 (1.19 - 1.59)*** ** |
| Mother's Age at First Birth (vs. 25-29) | | | |
| <18 | | | **1.54 (1.28 - 1.86)*** ** |
| 18-19 | | | **1.76 (1.49 - 2.08)*** ** |
| 20-24 | | | **1.63 (1.43 - 1.86)*** ** |
| 30-34 | | | 1.03 (0.88 - 1.21) |
| 35+ | | | 1.15 (0.90 - 1.47) |
| Large Family (4+), Age 4 | | | **1.24 (1.06 - 1.44)** ** |
| Received Support or Protection Services | | | **1.90 (1.65 - 2.18)*** ** |
| Child in Care | | | **1.53 (1.27 - 1.85)*** ** |
| | c=0.65 | c=0.66 | c= 0.73 |

*** p <.0001, ** p <.01, * p <.05

### Specific EDI domains

***Language and Cognitive.*** Children born late preterm were significantly more likely to be not ready in the language and cognitive domain of development after considering medical and social factors. In model 3, the odds of being not ready were 1.29 times higher in the late preterm group, 2.19 times higher among males compared to females, and children who were younger at the time of assessment were more likely to be not ready. Based on model 3, medical variables with significant associations in this model included being SGA (OR=1.30, p<.01), maternal diabetes (OR=1.32, p<.05) and a high number of diagnoses during the first year of life (OR=1.06, p<.0001). Those born LGA had 16% greater odds of being not ready (p<.05). Social variables associated with not being ready in the language and cognitive domain include receipt of income assistance at age 4 (OR=1.70, p<.0001), living in a low income neighbourhood (OR=1.29, p<.01), being a young mother at the time of first birth, having 4 or more children in the family (OR=1.30, p<.01), and involvement with CFS for support or protection services (OR=1.65, p<.001) or for placement in care (OR=1.39, p<01). Older maternal age at first birth was associated with lower odds of being not ready in the language and cognitive domain of development.

*Table 13: Logistic Regression Models of 'not ready' in language and cognitive domain (n=16,327)*



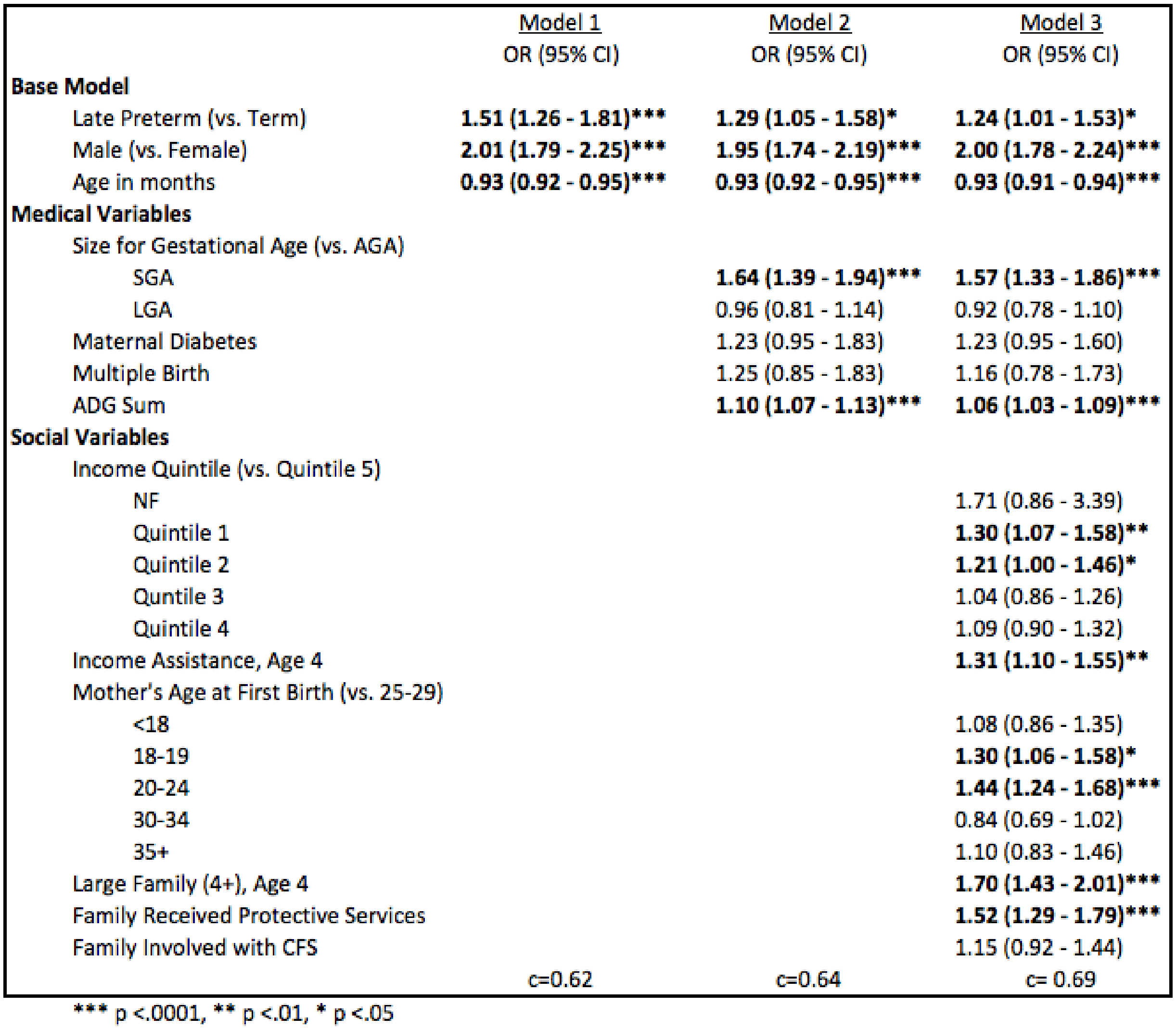
| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) |
|---|---|---|---|
| **Base Model** | | | |
| Late Preterm (vs. Term) | **1.61 (1.36 - 1.90)*** ** | **1.34 (1.11 - 1.62)** ** | **1.29 (1.06 - 1.57)* ** |
| Male (vs. Female) | **2.13 (1.92 - 2.37)*** ** | **2.06 (1.85 - 2.29)*** ** | **2.19 (1.96 - 2.44)*** ** |
| Age in months | **0.92 (0.91 - 0.93)*** ** | **0.92 (0.90 - 0.93)*** ** | **0.91 (0.90 - 0.92)*** ** |
| **Medical Variables** | | | |
| Size for Gestational Age (vs. AGA) | | | |
| SGA | | **1.39 (1.18 - 1.63)*** ** | **1.30 (1.10 - 1.54)** ** |
| LGA | | 0.88 (0.75 - 1.03) | **0.84 (0.71 - 0.99)* ** |
| Maternal Diabetes | | 1.27 (1.00 - 1.61) | **1.32 (1.03 - 1.70)* ** |
| Multiple Birth | | 1.25 (0.87 - 1.79) | 1.30 (0.89 - 1.90) |
| ADG Sum | | **1.12 (1.10 - 1.15)*** ** | **1.06 (1.03 - 1.70)*** ** |
| **Social Variables** | | | |
| Income Quintile (vs. Quintile 5) | | | |
| NF | | | 1.72 (0.93 - 3.16) |
| Quintile 1 | | | **1.29 (1.07 - 1.55)** ** |
| Quintile 2 | | | 1.16 (0.97 - 1.39) |
| Quntile 3 | | | 0.98 (0.82 - 1.18) |
| Quintile 4 | | | 1.04 (0.87 - 1.25) |
| Income Assistance, Age 4 | | | **1.70 (1.46 - 1.98)*** ** |
| Mother's Age at First Birth (vs. 25-29) | | | |
| <18 | | | **1.64 (1.34 - 2.01)*** ** |
| 18-19 | | | **1.66 (1.37 - 1.99)*** ** |
| 20-24 | | | **1.59 (1.37 - 1.85)*** ** |
| 30-34 | | | **0.74 (0.61 - 0.90)** ** |
| 35+ | | | 0.97 (0.73 - 1.30) |
| Large Family (4+), Age 4 | | | **1.30 (1.10 - 1.53)** ** |
| Received Support or Protection Services | | | **1.65 (1.42 - 1.92)*** ** |
| Child in Care | | | **1.39 (1.14 - 1.70)** ** |
| | c=0.64 | c=0.66 | c= 0.74 |

*** p <.0001, ** p <.01, * p <.05

***Communication and General Knowledge.*** After controlling for medical and social factors, children born late preterm had significantly higher odds of being not ready in the communication and general knowledge domain compared to those born at term (OR=1.24, p<.05). Based on model 3, additional factors that were significantly associated with the outcome were male sex (2.00, p<.0001), being born SGA (OR=1.57, p<.0001), having more as opposed to fewer diagnoses in the first year of life (OR=1.06, p<.0001), being 20-24 (OR=1.44, p<.0001) followed by 18-19 (OR=1.30, p<.05) years old at time of first birth, having 4 or more children in the family (OR=1.70, p<.0001), and receiving support or protection services from CFS

(OR=1.52, p<.0001). There was a gradient by income quintile, where receipt of income assistance (OR=1.31, p<.01), and income quintiles 1 (OR=1.30, p<.01) and 2 (OR=1.21, p<.05) were found to have higher odds of poor communication and general knowledge development compared to those in higher income quintiles.

*Table 14: Logistic Regression Models of 'not ready' in communication and general knowledge domain (n=16,418)*

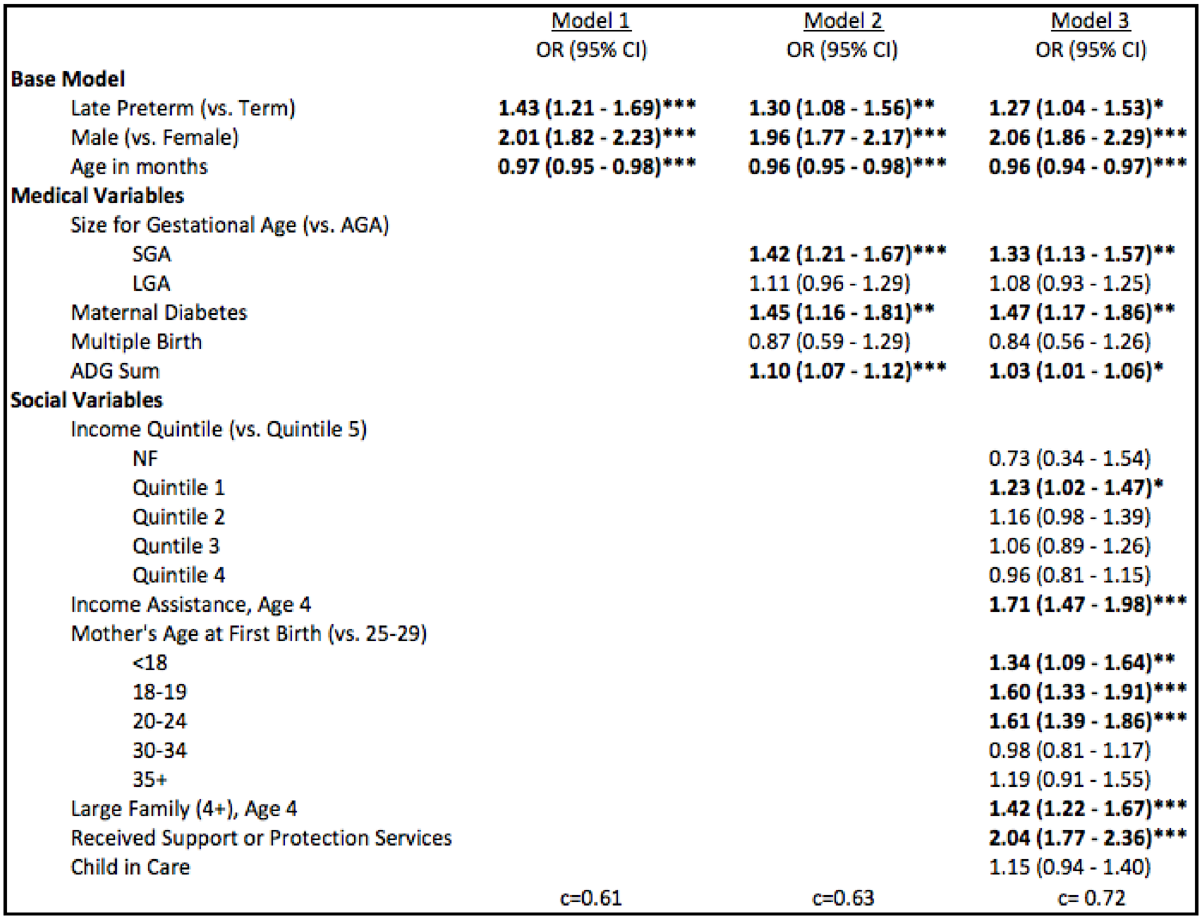


| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) |
|---|---|---|---|
| **Base Model** | | | |
| Late Preterm (vs. Term) | **1.51 (1.26 - 1.81)***** | **1.29 (1.05 - 1.58)*** | **1.24 (1.01 - 1.53)*** |
| Male (vs. Female) | **2.01 (1.79 - 2.25)***** | **1.95 (1.74 - 2.19)***** | **2.00 (1.78 - 2.24)***** |
| Age in months | **0.93 (0.92 - 0.95)***** | **0.93 (0.92 - 0.95)***** | **0.93 (0.91 - 0.94)***** |
| **Medical Variables** | | | |
| Size for Gestational Age (vs. AGA) | | | |
| SGA | | **1.64 (1.39 - 1.94)***** | **1.57 (1.33 - 1.86)***** |
| LGA | | 0.96 (0.81 - 1.14) | 0.92 (0.78 - 1.10) |
| Maternal Diabetes | | 1.23 (0.95 - 1.83) | 1.23 (0.95 - 1.60) |
| Multiple Birth | | 1.25 (0.85 - 1.83) | 1.16 (0.78 - 1.73) |
| ADG Sum | | **1.10 (1.07 - 1.13)***** | **1.06 (1.03 - 1.09)***** |
| **Social Variables** | | | |
| Income Quintile (vs. Quintile 5) | | | |
| NF | | | 1.71 (0.86 - 3.39) |
| Quintile 1 | | | **1.30 (1.07 - 1.58)**** |
| Quintile 2 | | | **1.21 (1.00 - 1.46)*** |
| Quntile 3 | | | 1.04 (0.86 - 1.26) |
| Quintile 4 | | | 1.09 (0.90 - 1.32) |
| Income Assistance, Age 4 | | | **1.31 (1.10 - 1.55)**** |
| Mother's Age at First Birth (vs. 25-29) | | | |
| <18 | | | 1.08 (0.86 - 1.35) |
| 18-19 | | | **1.30 (1.06 - 1.58)*** |
| 20-24 | | | **1.44 (1.24 - 1.68)***** |
| 30-34 | | | 0.84 (0.69 - 1.02) |
| 35+ | | | 1.10 (0.83 - 1.46) |
| Large Family (4+), Age 4 | | | **1.70 (1.43 - 2.01)***** |
| Family Received Protective Services | | | **1.52 (1.29 - 1.79)***** |
| Family Involved with CFS | | | 1.15 (0.92 - 1.44) |
| | c=0.62 | c=0.64 | c= 0.69 |

*** p <.0001, ** p <.01, * p <.05

***Physical Health and Well-being.*** After controlling for medical and social factors, the odds of being not ready in the physical health and well-being domain were 27% greater in the late preterm population compared to those born at term (p<.05). Males had twice the odds of being not ready (p<.0001) and being younger at the time of assessment was associated with lower odds of being not ready (p<.0001). Maternal diabetes during pregnancy (OR=1.47, p<.01), being born SGA (OR=1.33, p<.01), and having poor health during the first year of life (OR=1.03, p<.05) all increased the odds of being not physically ready for school. Again, being from a low income family (on income assistance or in quintile 1) was associated with increased odds of 71 and 23%, respectively. A mother's age at first birth of 20-24, followed by 18-19 and <18 increased the odds by 61, 60 and 34% compared to a mother's age at first birth in the 25-29 age range. Receiving support or protection services at any time before a child's 8th birthday was associated with increased odds of poor physical health and well-being of more than 2 times (OR=2.04, p<.0001), and being in a family with 4 or more children was associated with increased odds of 1.42 times (p<.0001).

*Table 15: Logistic Regression Models of 'not ready' in physical health and well-being domain (n=16,390)*

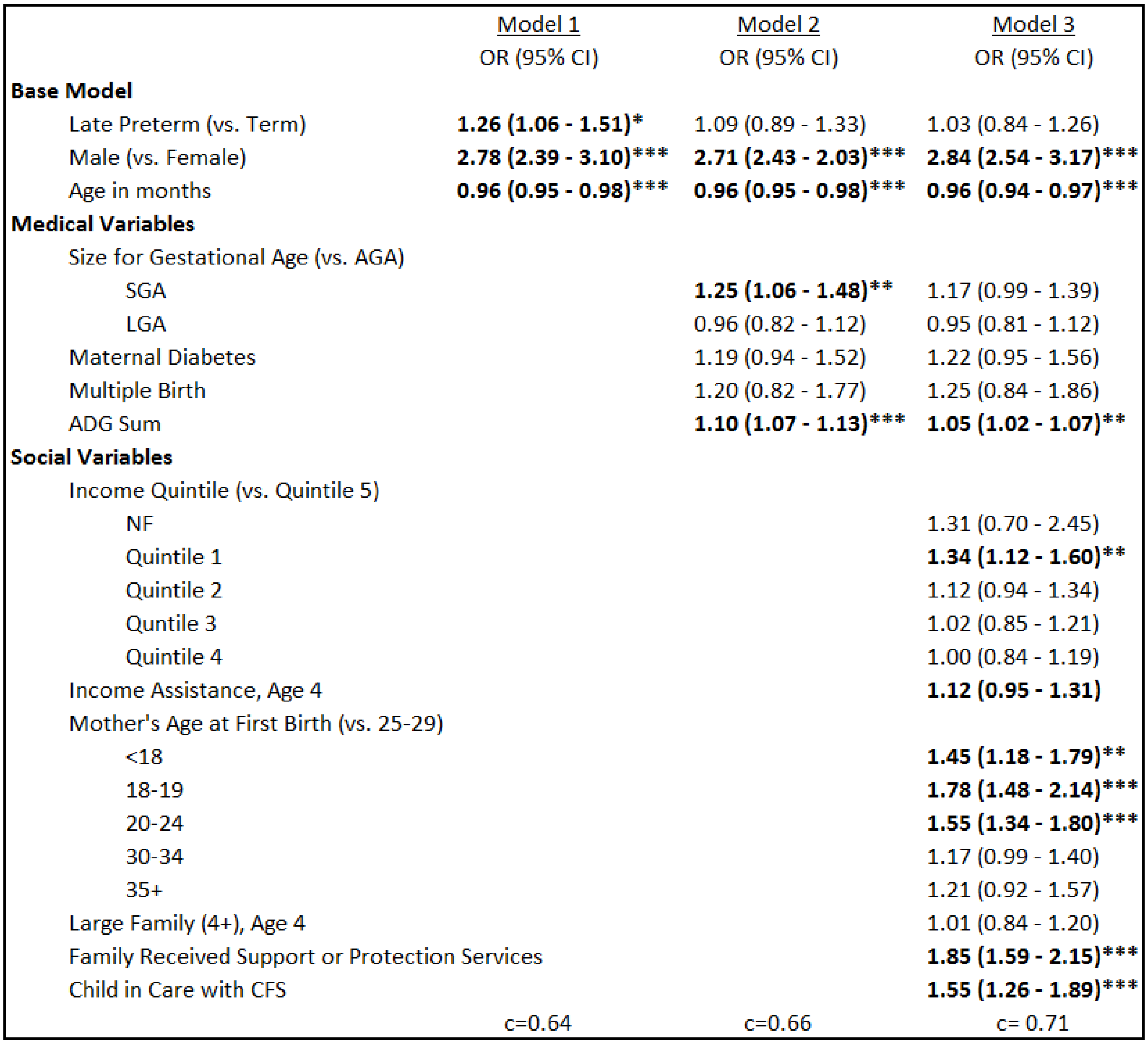


| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) |
|---|---|---|---|
| **Base Model** | | | |
| Late Preterm (vs. Term) | **1.43 (1.21 - 1.69)*** ** | **1.30 (1.08 - 1.56)** ** | **1.27 (1.04 - 1.53)* ** |
| Male (vs. Female) | **2.01 (1.82 - 2.23)*** ** | **1.96 (1.77 - 2.17)*** ** | **2.06 (1.86 - 2.29)*** ** |
| Age in months | **0.97 (0.95 - 0.98)*** ** | **0.96 (0.95 - 0.98)*** ** | **0.96 (0.94 - 0.97)*** ** |
| **Medical Variables** | | | |
| Size for Gestational Age (vs. AGA) | | | |
| SGA | | **1.42 (1.21 - 1.67)*** ** | **1.33 (1.13 - 1.57)** ** |
| LGA | | 1.11 (0.96 - 1.29) | 1.08 (0.93 - 1.25) |
| Maternal Diabetes | | **1.45 (1.16 - 1.81)** ** | **1.47 (1.17 - 1.86)** ** |
| Multiple Birth | | 0.87 (0.59 - 1.29) | 0.84 (0.56 - 1.26) |
| ADG Sum | | **1.10 (1.07 - 1.12)*** ** | **1.03 (1.01 - 1.06)* ** |
| **Social Variables** | | | |
| Income Quintile (vs. Quintile 5) | | | |
| NF | | | 0.73 (0.34 - 1.54) |
| Quintile 1 | | | **1.23 (1.02 - 1.47)* ** |
| Quintile 2 | | | 1.16 (0.98 - 1.39) |
| Quntile 3 | | | 1.06 (0.89 - 1.26) |
| Quintile 4 | | | 0.96 (0.81 - 1.15) |
| Income Assistance, Age 4 | | | **1.71 (1.47 - 1.98)*** ** |
| Mother's Age at First Birth (vs. 25-29) | | | |
| <18 | | | **1.34 (1.09 - 1.64)** ** |
| 18-19 | | | **1.60 (1.33 - 1.91)*** ** |
| 20-24 | | | **1.61 (1.39 - 1.86)*** ** |
| 30-34 | | | 0.98 (0.81 - 1.17) |
| 35+ | | | 1.19 (0.91 - 1.55) |
| Large Family (4+), Age 4 | | | **1.42 (1.22 - 1.67)*** ** |
| Received Support or Protection Services | | | **2.04 (1.77 - 2.36)*** ** |
| Child in Care | | | 1.15 (0.94 - 1.40) |
| | c=0.61 | c=0.63 | c= 0.72 |

*** p <.0001, ** p <.01, * p <.05

***Social Competence.*** The odds of being not ready in the social competence domain were not significantly different between children born late preterm and children born at term after controlling for other factors. Model 3 demonstrates that males have almost 3 times the odds of being not be ready in this domain (p<.0001) and poor health status during the first year of life was associated with a small increase in the odds (OR=1.05, p<.01). Income quintile 1 was the only income quintile found to be associated with being not ready in the social competence domain (OR=1.34, p<.01). Mother's age at first birth of 18-19 years of age (OR=1.78, p<.0001), followed by ages 20-24 (OR=1.55, p<.0001) and <18 years of age (OR=1.45, p<.01) were all associated with increased odds of being not ready. Finally, being placed in care or receiving support or protection services was associated with increased odds of being not ready in the social competence domain of 1.55 and 1.85 times (p<.0001).

*Table 16: Logistic Regression Models of 'not ready' in social competence domain (n=16,415)*

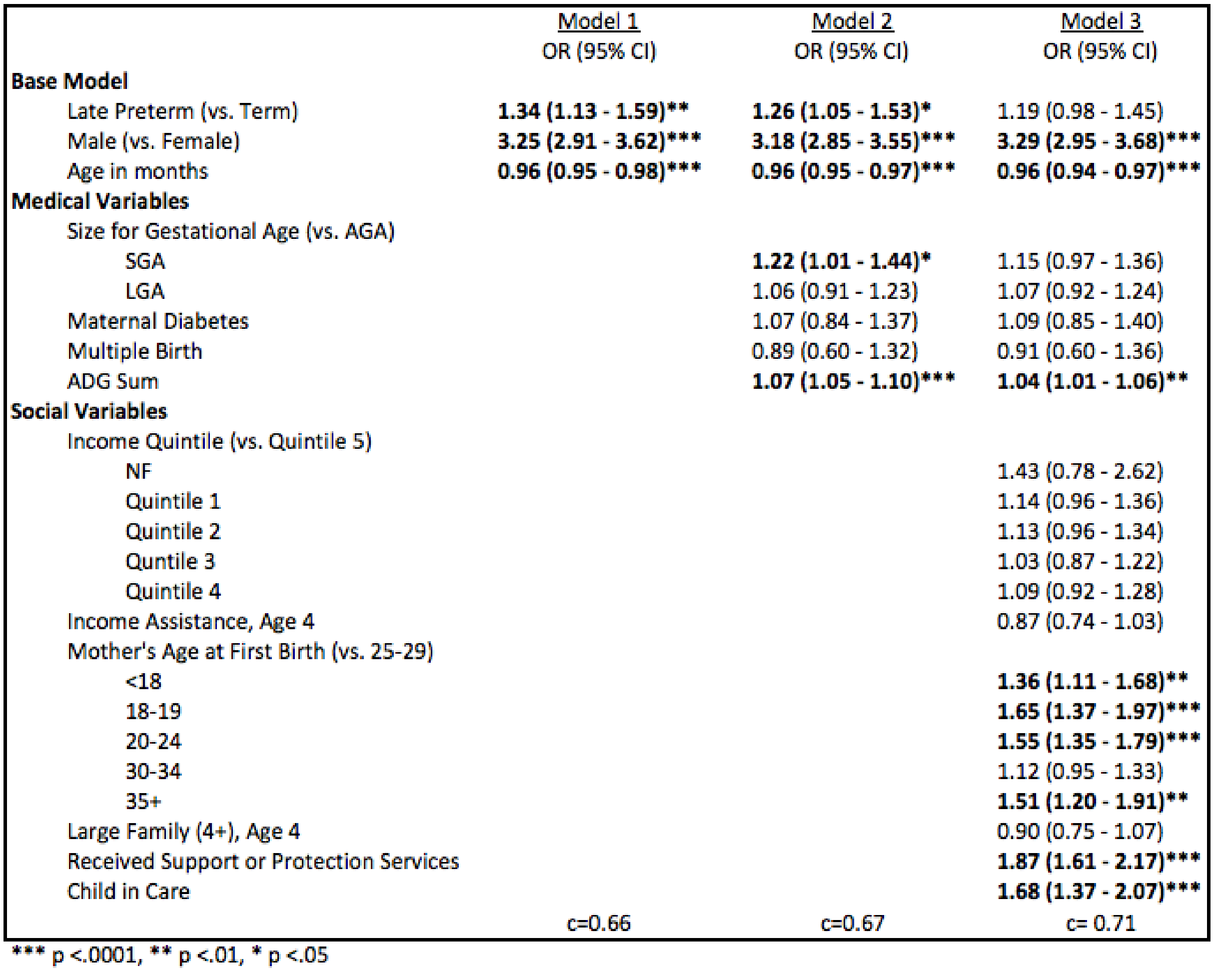


| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) |
|---|---|---|---|
| **Base Model** | | | |
| Late Preterm (vs. Term) | **1.26 (1.06 - 1.51)*** | 1.09 (0.89 - 1.33) | 1.03 (0.84 - 1.26) |
| Male (vs. Female) | **2.78 (2.39 - 3.10)***** | **2.71 (2.43 - 2.03)***** | **2.84 (2.54 - 3.17)***** |
| Age in months | **0.96 (0.95 - 0.98)***** | **0.96 (0.95 - 0.98)***** | **0.96 (0.94 - 0.97)***** |
| **Medical Variables** | | | |
| Size for Gestational Age (vs. AGA) | | | |
| SGA | | **1.25 (1.06 - 1.48)**** | 1.17 (0.99 - 1.39) |
| LGA | | 0.96 (0.82 - 1.12) | 0.95 (0.81 - 1.12) |
| Maternal Diabetes | | 1.19 (0.94 - 1.52) | 1.22 (0.95 - 1.56) |
| Multiple Birth | | 1.20 (0.82 - 1.77) | 1.25 (0.84 - 1.86) |
| ADG Sum | | **1.10 (1.07 - 1.13)***** | **1.05 (1.02 - 1.07)**** |
| **Social Variables** | | | |
| Income Quintile (vs. Quintile 5) | | | |
| NF | | | 1.31 (0.70 - 2.45) |
| Quintile 1 | | | **1.34 (1.12 - 1.60)**** |
| Quintile 2 | | | 1.12 (0.94 - 1.34) |
| Quntile 3 | | | 1.02 (0.85 - 1.21) |
| Quintile 4 | | | 1.00 (0.84 - 1.19) |
| Income Assistance, Age 4 | | | **1.12 (0.95 - 1.31)** |
| Mother's Age at First Birth (vs. 25-29) | | | |
| <18 | | | **1.45 (1.18 - 1.79)**** |
| 18-19 | | | **1.78 (1.48 - 2.14)***** |
| 20-24 | | | **1.55 (1.34 - 1.80)***** |
| 30-34 | | | 1.17 (0.99 - 1.40) |
| 35+ | | | 1.21 (0.92 - 1.57) |
| Large Family (4+), Age 4 | | | 1.01 (0.84 - 1.20) |
| Family Received Support or Protection Services | | | **1.85 (1.59 - 2.15)***** |
| Child in Care with CFS | | | **1.55 (1.26 - 1.89)***** |
| | c=0.64 | c=0.66 | c= 0.71 |

*** p<.0001, ** p<.01, * p<.05

***Emotional Maturity.*** Although the children born late preterm had 1.26 times the odds of being not ready in the emotional maturity domain of the EDI when base (model 1) and medical factors (model 2) were included in the models, this effect disappeared once social factors (model 3) were entered into the model. In model 3, males had 3.28 times the odds of being not ready and those who were older at time of assessment had lower odds of being not ready. With the exception of health status during the first year of life, medical variables were not significant in the full model, nor was income. Young (<25) and older (35+) maternal age at first birth, being in care (OR=1.68, p<.0001) and receiving support and protection services (OR=1.87, p<.0001) were all found to significantly increase the odds of being not ready in the emotional domain.

*Table 17: Logistic Regression Models of 'not ready' in emotional maturity domain (n=16,306)*

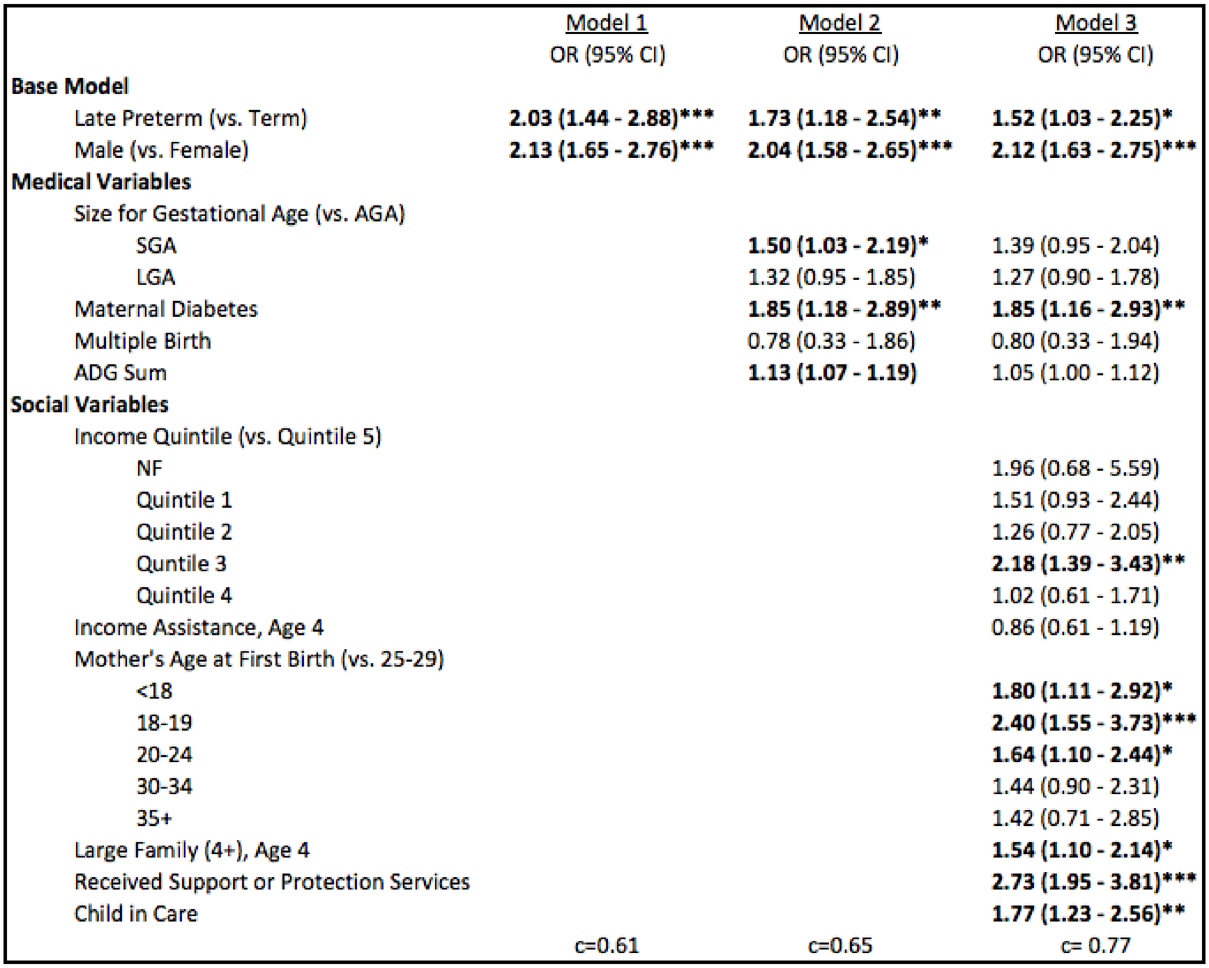


| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) |
|---|---|---|---|
| **Base Model** | | | |
| Late Preterm (vs. Term) | **1.34 (1.13 - 1.59)**** | **1.26 (1.05 - 1.53)*** | 1.19 (0.98 - 1.45) |
| Male (vs. Female) | **3.25 (2.91 - 3.62)***** | **3.18 (2.85 - 3.55)***** | **3.29 (2.95 - 3.68)***** |
| Age in months | **0.96 (0.95 - 0.98)***** | **0.96 (0.95 - 0.97)***** | **0.96 (0.94 - 0.97)***** |
| **Medical Variables** | | | |
| Size for Gestational Age (vs. AGA) | | | |
| SGA | | **1.22 (1.01 - 1.44)*** | 1.15 (0.97 - 1.36) |
| LGA | | 1.06 (0.91 - 1.23) | 1.07 (0.92 - 1.24) |
| Maternal Diabetes | | 1.07 (0.84 - 1.37) | 1.09 (0.85 - 1.40) |
| Multiple Birth | | 0.89 (0.60 - 1.32) | 0.91 (0.60 - 1.36) |
| ADG Sum | | **1.07 (1.05 - 1.10)***** | **1.04 (1.01 - 1.06)**** |
| **Social Variables** | | | |
| Income Quintile (vs. Quintile 5) | | | |
| NF | | | 1.43 (0.78 - 2.62) |
| Quintile 1 | | | 1.14 (0.96 - 1.36) |
| Quintile 2 | | | 1.13 (0.96 - 1.34) |
| Quntile 3 | | | 1.03 (0.87 - 1.22) |
| Quintile 4 | | | 1.09 (0.92 - 1.28) |
| Income Assistance, Age 4 | | | 0.87 (0.74 - 1.03) |
| Mother's Age at First Birth (vs. 25-29) | | | |
| <18 | | | **1.36 (1.11 - 1.68)**** |
| 18-19 | | | **1.65 (1.37 - 1.97)***** |
| 20-24 | | | **1.55 (1.35 - 1.79)***** |
| 30-34 | | | 1.12 (0.95 - 1.33) |
| 35+ | | | **1.51 (1.20 - 1.91)**** |
| Large Family (4+), Age 4 | | | 0.90 (0.75 - 1.07) |
| Received Support or Protection Services | | | **1.87 (1.61 - 2.17)***** |
| Child in Care | | | **1.68 (1.37 - 2.07)***** |
| | c=0.66 | c=0.67 | c= 0.71 |

*** p <.0001, ** p <.01, * p <.05

***Grade Repetition.*** Model 1 demonstrates that the odds of repeating kindergarten or grade 1 were 2.03 times higher among children born late preterm. This effect diminished, but remained significant in models 2 and 3, with 1.52 times greater odds of grade repetition compared to those born at term in model 3 (p<.05). Additional factors associated with grade repetition in model 3 included maternal diabetes (OR=1.85, p<.01) and male sex (OR=2.12, p<.0001). Middle income children had elevated odds of 2.18 times for grade repetition (p<.01), and being a young mother at first birth, particularly in the 18-19 range, elevated those odds. The odds were found to be almost 3 times higher among children whose families received support or protection services, 1.77 times higher among those who were in care with CFS at any point, and those in a family with 4 or more children (OR=1.54, p<.05).

*Table 18: Logistic Regression Models of Grade Repetition (n=27,637)*

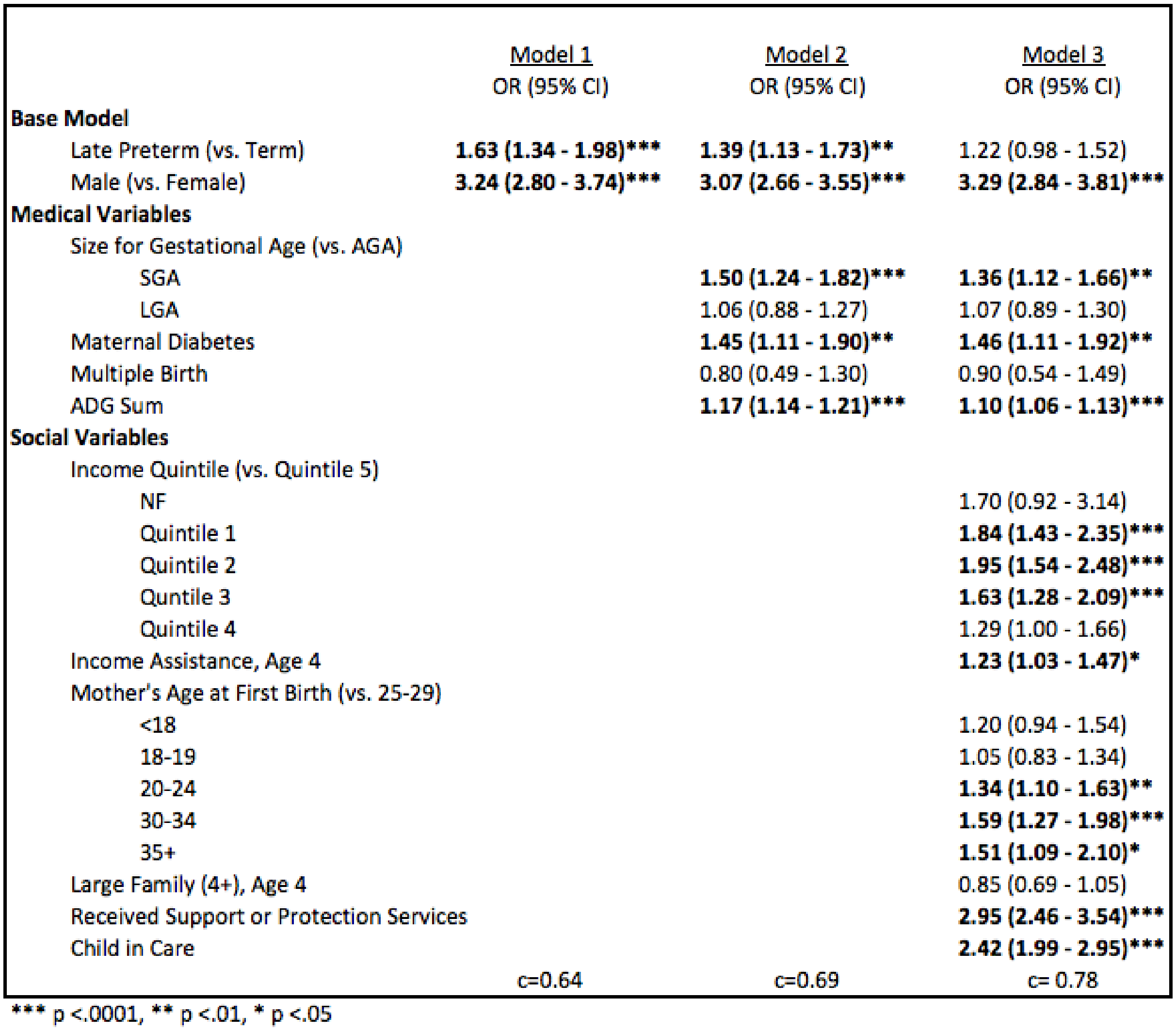


| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) |
|---|---|---|---|
| **Base Model** | | | |
| Late Preterm (vs. Term) | **2.03 (1.44 - 2.88)*** | **1.73 (1.18 - 2.54)**** | **1.52 (1.03 - 2.25)*** |
| Male (vs. Female) | **2.13 (1.65 - 2.76)***** | **2.04 (1.58 - 2.65)***** | **2.12 (1.63 - 2.75)***** |
| **Medical Variables** | | | |
| Size for Gestational Age (vs. AGA) | | | |
| SGA | | **1.50 (1.03 - 2.19)*** | 1.39 (0.95 - 2.04) |
| LGA | | 1.32 (0.95 - 1.85) | 1.27 (0.90 - 1.78) |
| Maternal Diabetes | | **1.85 (1.18 - 2.89)**** | **1.85 (1.16 - 2.93)**** |
| Multiple Birth | | 0.78 (0.33 - 1.86) | 0.80 (0.33 - 1.94) |
| ADG Sum | | **1.13 (1.07 - 1.19)** | 1.05 (1.00 - 1.12) |
| **Social Variables** | | | |
| Income Quintile (vs. Quintile 5) | | | |
| NF | | | 1.96 (0.68 - 5.59) |
| Quintile 1 | | | 1.51 (0.93 - 2.44) |
| Quintile 2 | | | 1.26 (0.77 - 2.05) |
| Quntile 3 | | | **2.18 (1.39 - 3.43)**** |
| Quintile 4 | | | 1.02 (0.61 - 1.71) |
| Income Assistance, Age 4 | | | 0.86 (0.61 - 1.19) |
| Mother's Age at First Birth (vs. 25-29) | | | |
| <18 | | | **1.80 (1.11 - 2.92)*** |
| 18-19 | | | **2.40 (1.55 - 3.73)***** |
| 20-24 | | | **1.64 (1.10 - 2.44)*** |
| 30-34 | | | 1.44 (0.90 - 2.31) |
| 35+ | | | 1.42 (0.71 - 2.85) |
| Large Family (4+), Age 4 | | | **1.54 (1.10 - 2.14)*** |
| Received Support or Protection Services | | | **2.73 (1.95 - 3.81)***** |
| Child in Care | | | **1.77 (1.23 - 2.56)**** |
| | c=0.61 | c=0.65 | c= 0.77 |

*** p <.0001, ** p <.01, * p <.05

***Receipt of Special Education Funding.*** Receipt of special education funding was not significantly associated with prematurity at the late preterm stage once base, medical and social factors were taken into consideration. Without the inclusion of social factors, the odds of receiving special education funding were 1.63 (p<.0001) and 1.39 (p<.01) times higher in the base and base plus medical models. Males had 3.29 times the odds of receiving funding (p<.0001), and being born SGA (OR=1.36, p<.01), poor health status during the first year of life (OR=1.10, p<.0001), and maternal diabetes (OR=1.46, p<.01) were all significantly associated with higher odds of funding in model 3. Those in low to moderate income quintiles were found to have from 63 to 95% greater odds of receiving funding than those living in high income neighbourhoods (p<.0001) and those receiving income assistance at age 4 had 23% higher odds compared to those who were not (p<.05). Unlike other outcomes examined, older maternal age, particularly in the 30 to 34 age range, was associated with elevated odds (OR=1.59, p<.0001), followed by those 35 and over (OR=1.51, p<.05) and those 20-24 (OR=1.34, p<.01), compared to those giving birth at age 25-29. Receiving support and protection services and being placed in care were also found to significantly increase the odds by 2.95 and 2.42 times (p<.0001).

*Table 19: Logistic Regression Models of Receipt of Special Education Funding (n=28,100)*

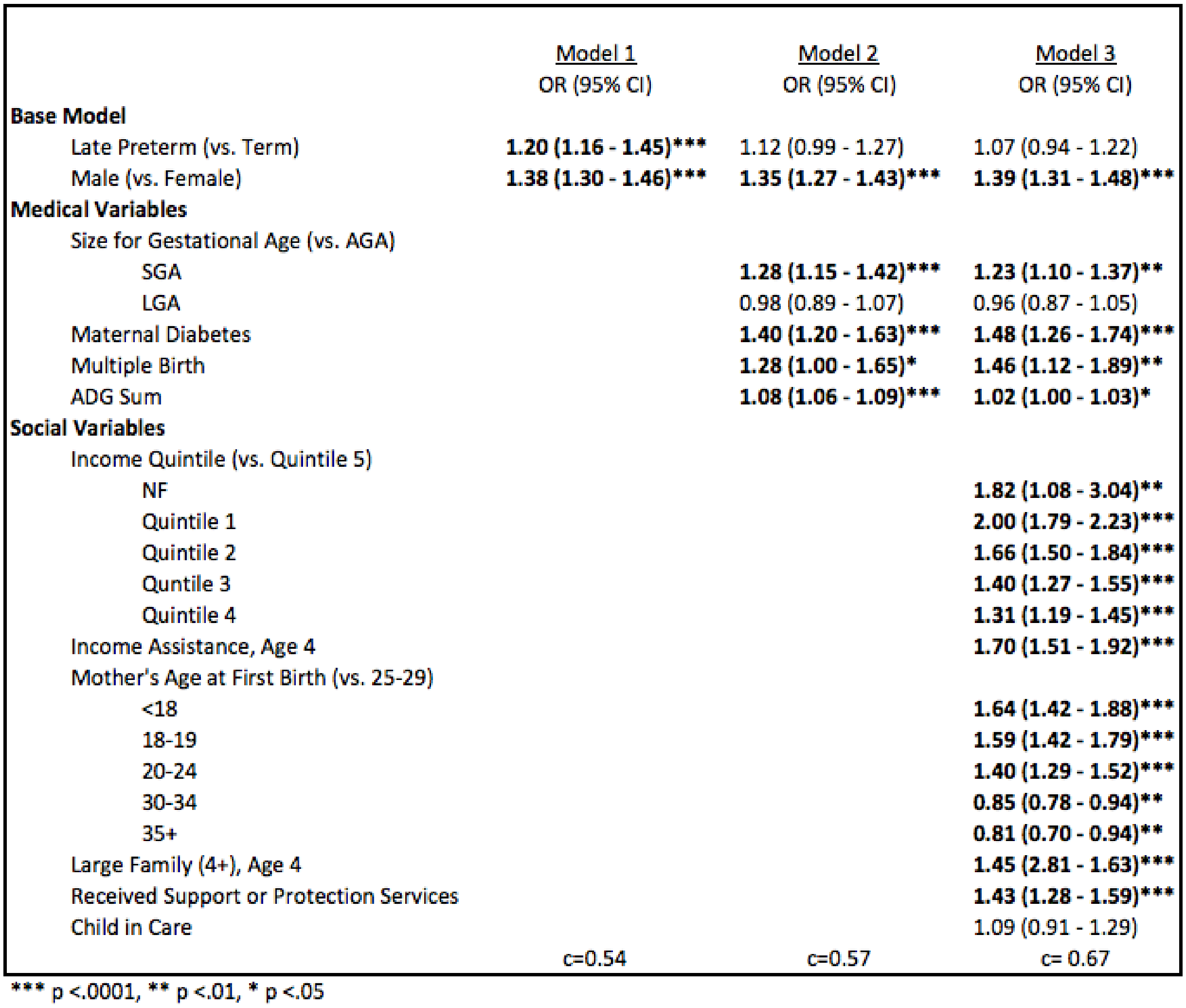


| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) |
|---|---|---|---|
| **Base Model** | | | |
| Late Preterm (vs. Term) | **1.63 (1.34 - 1.98)***** | **1.39 (1.13 - 1.73)**** | 1.22 (0.98 - 1.52) |
| Male (vs. Female) | **3.24 (2.80 - 3.74)***** | **3.07 (2.66 - 3.55)***** | **3.29 (2.84 - 3.81)***** |
| **Medical Variables** | | | |
| Size for Gestational Age (vs. AGA) | | | |
| SGA | | **1.50 (1.24 - 1.82)***** | **1.36 (1.12 - 1.66)**** |
| LGA | | 1.06 (0.88 - 1.27) | 1.07 (0.89 - 1.30) |
| Maternal Diabetes | | **1.45 (1.11 - 1.90)**** | **1.46 (1.11 - 1.92)**** |
| Multiple Birth | | 0.80 (0.49 - 1.30) | 0.90 (0.54 - 1.49) |
| ADG Sum | | **1.17 (1.14 - 1.21)***** | **1.10 (1.06 - 1.13)***** |
| **Social Variables** | | | |
| Income Quintile (vs. Quintile 5) | | | |
| NF | | | 1.70 (0.92 - 3.14) |
| Quintile 1 | | | **1.84 (1.43 - 2.35)***** |
| Quintile 2 | | | **1.95 (1.54 - 2.48)***** |
| Quntile 3 | | | **1.63 (1.28 - 2.09)***** |
| Quintile 4 | | | 1.29 (1.00 - 1.66) |
| Income Assistance, Age 4 | | | **1.23 (1.03 - 1.47)*** |
| Mother's Age at First Birth (vs. 25-29) | | | |
| <18 | | | 1.20 (0.94 - 1.54) |
| 18-19 | | | 1.05 (0.83 - 1.34) |
| 20-24 | | | **1.34 (1.10 - 1.63)**** |
| 30-34 | | | **1.59 (1.27 - 1.98)***** |
| 35+ | | | **1.51 (1.09 - 2.10)*** |
| Large Family (4+), Age 4 | | | 0.85 (0.69 - 1.05) |
| Received Support or Protection Services | | | **2.95 (2.46 - 3.54)***** |
| Child in Care | | | **2.42 (1.99 - 2.95)***** |
| | c=0.64 | c=0.69 | c= 0.78 |

*** p <.0001, ** p <.01, * p <.05

***Grade 3 Reading Assessments.*** Elevated odds for not meeting or approaching expectations in grade 3 reading assessments were found only in model 1, where children born late preterm were found to have 20% higher odds of not meeting expectations (p<.0001). Poorer reading performance was found to be associated with both medical and social factors, where all but LGA and being a child in care with CFS was associated with elevated odds of not meeting or approaching expectation in grade 3 reading. Unlike previous models, a clear gradient was observed for both income and maternal age, where each increase in income and maternal age was associated with lower odds of not meeting expectations.

*Table 20: Logistic Regression of not meeting or approaching expectations in grade 3 reading assessments (n=18,275)*

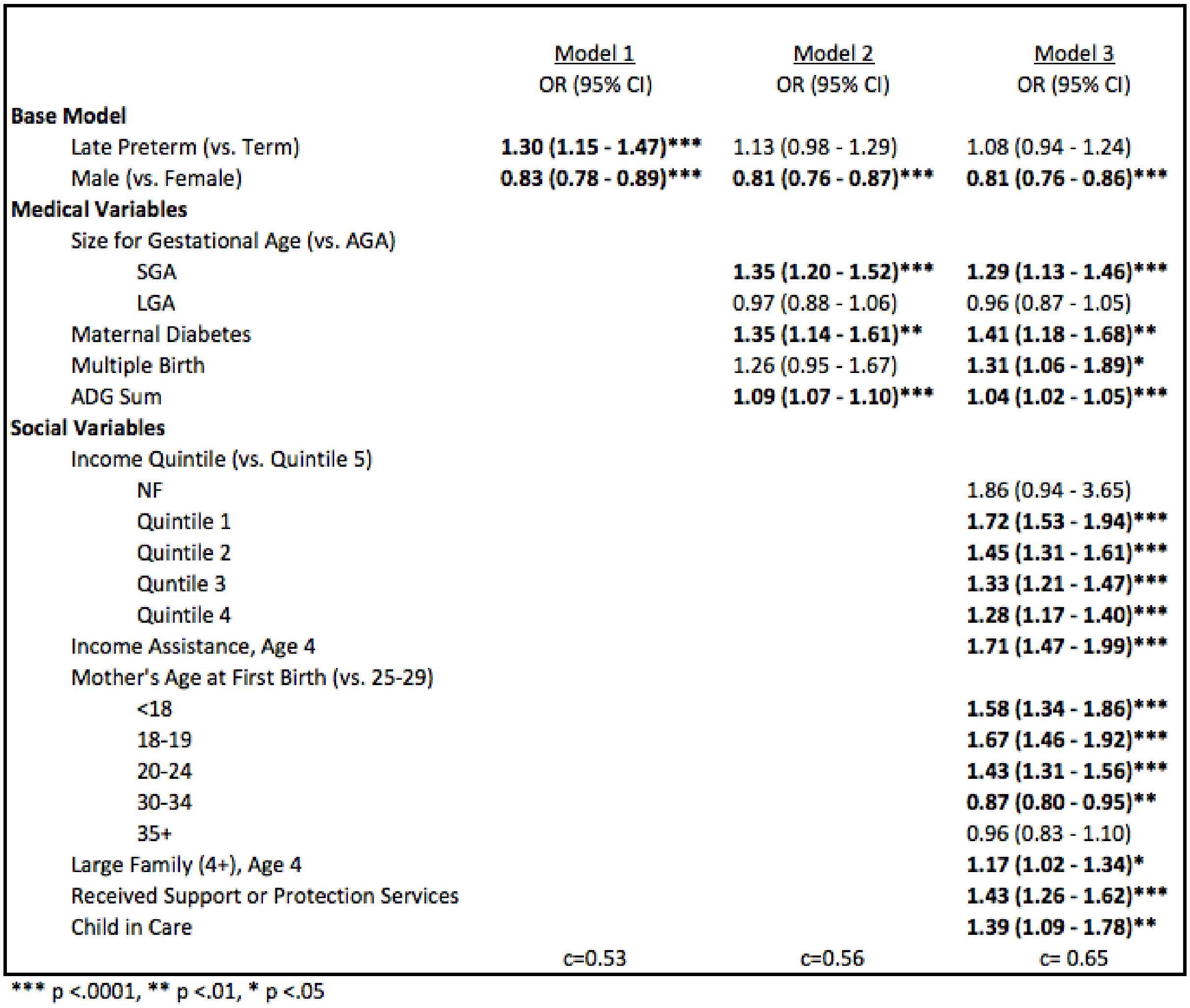


| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) |
|---|---|---|---|
| **Base Model** | | | |
| Late Preterm (vs. Term) | **1.20 (1.16 - 1.45)***** | 1.12 (0.99 - 1.27) | 1.07 (0.94 - 1.22) |
| Male (vs. Female) | **1.38 (1.30 - 1.46)***** | **1.35 (1.27 - 1.43)***** | **1.39 (1.31 - 1.48)***** |
| **Medical Variables** | | | |
| Size for Gestational Age (vs. AGA) | | | |
| SGA | | **1.28 (1.15 - 1.42)***** | **1.23 (1.10 - 1.37)**** |
| LGA | | 0.98 (0.89 - 1.07) | 0.96 (0.87 - 1.05) |
| Maternal Diabetes | | **1.40 (1.20 - 1.63)***** | **1.48 (1.26 - 1.74)***** |
| Multiple Birth | | **1.28 (1.00 - 1.65)*** | **1.46 (1.12 - 1.89)**** |
| ADG Sum | | **1.08 (1.06 - 1.09)***** | **1.02 (1.00 - 1.03)*** |
| **Social Variables** | | | |
| Income Quintile (vs. Quintile 5) | | | |
| NF | | | **1.82 (1.08 - 3.04)**** |
| Quintile 1 | | | **2.00 (1.79 - 2.23)***** |
| Quintile 2 | | | **1.66 (1.50 - 1.84)***** |
| Quntile 3 | | | **1.40 (1.27 - 1.55)***** |
| Quintile 4 | | | **1.31 (1.19 - 1.45)***** |
| Income Assistance, Age 4 | | | **1.70 (1.51 - 1.92)***** |
| Mother's Age at First Birth (vs. 25-29) | | | |
| <18 | | | **1.64 (1.42 - 1.88)***** |
| 18-19 | | | **1.59 (1.42 - 1.79)***** |
| 20-24 | | | **1.40 (1.29 - 1.52)***** |
| 30-34 | | | **0.85 (0.78 - 0.94)**** |
| 35+ | | | **0.81 (0.70 - 0.94)**** |
| Large Family (4+), Age 4 | | | **1.45 (2.81 - 1.63)***** |
| Received Support or Protection Services | | | **1.43 (1.28 - 1.59)***** |
| Child in Care | | | 1.09 (0.91 - 1.29) |
| | c=0.54 | c=0.57 | c= 0.67 |

*** p <.0001, ** p <.01, * p <.05

***Grade 3 Numeracy Assessments.*** Similarly, the association between late preterm and the odds of not meeting or approaching expectations in grade 3 numeracy assessments lost its strength once medical and social factors were taken in to consideration. Unlike all other outcomes examined, being a male was found to be associated with lower odds of not meeting or approaching expectations (OR=0.81, p<.0001). In congruence with the reading models, almost all medical and social factors were found to be significant in the models, with the exception of LGA and a maternal age at first birth of 35 or over. A gradient was observed for income, where lower income quintiles were associated with higher odds of poor outcomes, and in general, increasing maternal age was associated with better outcomes. Family receipt of support or protection services were associated with a 1.43 times greater odds of not meeting or approaching expectations ($p<.0001$), and being a child in care at any point up to the child's 8th birthday was associated with 1.39 times higher odds ($p<.01$). Finally, those with 4 or more children in the family had a 17% higher odds of not meeting or approaching expectations in numeracy ($p<.05$).

*Table 21: Logistic Regression of not meeting or approaching expectations in grade 3 numeracy assessments (n=18,275)*



| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) |
|---|---|---|---|
| **Base Model** | | | |
| Late Preterm (vs. Term) | **1.30 (1.15 - 1.47)***** | 1.13 (0.98 - 1.29) | 1.08 (0.94 - 1.24) |
| Male (vs. Female) | **0.83 (0.78 - 0.89)***** | **0.81 (0.76 - 0.87)***** | **0.81 (0.76 - 0.86)***** |
| **Medical Variables** | | | |
| Size for Gestational Age (vs. AGA) | | | |
| SGA | | **1.35 (1.20 - 1.52)***** | **1.29 (1.13 - 1.46)***** |
| LGA | | 0.97 (0.88 - 1.06) | 0.96 (0.87 - 1.05) |
| Maternal Diabetes | | **1.35 (1.14 - 1.61)**** | **1.41 (1.18 - 1.68)**** |
| Multiple Birth | | 1.26 (0.95 - 1.67) | **1.31 (1.06 - 1.89)*** |
| ADG Sum | | **1.09 (1.07 - 1.10)***** | **1.04 (1.02 - 1.05)***** |
| **Social Variables** | | | |
| Income Quintile (vs. Quintile 5) | | | |
| NF | | | 1.86 (0.94 - 3.65) |
| Quintile 1 | | | **1.72 (1.53 - 1.94)***** |
| Quintile 2 | | | **1.45 (1.31 - 1.61)***** |
| Quntile 3 | | | **1.33 (1.21 - 1.47)***** |
| Quintile 4 | | | **1.28 (1.17 - 1.40)***** |
| Income Assistance, Age 4 | | | **1.71 (1.47 - 1.99)***** |
| Mother's Age at First Birth (vs. 25-29) | | | |
| <18 | | | **1.58 (1.34 - 1.86)***** |
| 18-19 | | | **1.67 (1.46 - 1.92)***** |
| 20-24 | | | **1.43 (1.31 - 1.56)***** |
| 30-34 | | | **0.87 (0.80 - 0.95)**** |
| 35+ | | | 0.96 (0.83 - 1.10) |
| Large Family (4+), Age 4 | | | **1.17 (1.02 - 1.34)*** |
| Received Support or Protection Services | | | **1.43 (1.26 - 1.62)***** |
| Child in Care | | | **1.39 (1.09 - 1.78)**** |
| | c=0.53 | c=0.56 | c= 0.65 |

*** p <.0001, ** p <.01, * p <.05

**BF/FF Models.** The BF/FF models can be found in appendix B. These models yielded some findings that were consistent with the total sample and some findings that were not. The BF/FF variables were not statistically significant in any of the health models whereas at least one BF/FF variable was statistically significant in all EDI and educational models, most frequently ‘smoking during pregnancy’. Although adding the BF/FF variables may provide a more explanatory model, some of the highest risk families are excluded from these analyses, and thus, may be contributing to the inconsistent results. They are also less representative of the population of children born late preterm and term.

# Chapter 5: Discussion

Results from this study partially confirm the primary hypothesis, that children born late preterm have poorer health, development, and educational outcomes than children born at term. After controlling for several predictors of early childhood development, children born late preterm had significantly higher rates of LRTIs, asthma, and ADHD, but did not differ in health care utilization at ages 4 and 7 from children born at term. With respect to developmental vulnerability at school entry, children born late preterm were significantly more likely to be ‘not ready’ in the language and cognitive, communication and general knowledge, and physical health and well-being domains, but were no different than those born at term in the social competence and emotional maturity domains of development, or in the summary measures of ‘not ready’ in 1+ and 2+ domains. Children born late preterm were also significantly more likely to repeat kindergarten or grade 1, but were not more likely to receive special education funding. By the third grade, there were no significant differences in meeting or approaching expectations in reading and numeracy between children born late preterm and term, suggesting that as these children age, medical and social variables may have a greater effect than GA. For all outcomes examined the effect of GA diminished gradually as each set of variables (base, medical and social) were introduced into the models, which is consistent with the notion that there are multiple factors that impact early childhood development. In general, the findings were consistent with the existing body of literature that suggests poorer outcomes for children born late preterm.

## 5.1 The Health of children born late preterm in Manitoba

Of the health outcomes examined, respiratory conditions and ADHD during early childhood were most strongly associated with a GA of 34-36 weeks compared to a GA at term.

Prior to controlling for confounding variables, children born late preterm had almost double the odds of having an LRTI during the toddler and preschool years, and were also more likely to receive an asthma diagnosis between the ages of 6 and 8, and of being diagnosed with ADHD between the ages of 5 and 7. Although the Odds Ratios diminished when other covariates were added to the regression models, all three of these conditions remained statistically significantly higher for children born late preterm compared to term.

Findings of increased respiratory morbidity in this population are consistent with the literature that states that this population has poorer lung function right from birth (Pike & Lucas, 2014) and that early life lung development has been increasingly recognized as a determinant of later respiratory health (Stern, Morgan, Wright, Guerra, & Martinez, 2007). However, not all studies have been in agreement, especially at older ages (Pike & Lucas, 2014). In line with the results of this study are findings by Harju et al. (2014), which demonstrated statistically significantly higher odds of asthma among children born late preterm. Poorer lung function has also been found at ages 14 to 17 in this population, as well as higher rates of asthma in the early childhood period, but not by adolescence (Kotecha et al., 2013). Although findings by Goyal et al. (2011) do not support the association of late preterm birth with later asthma development, late prematurity in their study was associated with increased diagnosis of persistent asthma, greater receipt of inhaled corticosteroid prescription and a significant incident rate ratio for acute outpatient visits with wheeze at 18 months. Other findings are inconsistent with the results of the current study (Abe et al., 2010; Vogue et al., 2015).

In addition to the impact of respiratory influences on the development of asthma, links between immunity and asthma have been noted (Melville & Moss, 2013). Although one’s immune system takes time to develop for all children, its immaturity is more pronounced amongst those born preterm (Melville & Moss, 2013), which could also play a role in asthma development within this population.

### 5.3 Educational and Developmental outcomes of children born late preterm in Manitoba

Children born late preterm were statistically significantly more likely to be not ready for school in the language and cognitive, communication and general knowledge, and physical health and well-being domains of development in their kindergarten year. They were also more likely to repeat kindergarten or grade 1 compared to those born at term. No other educational outcomes differed between children born late preterm and at term after controlling for medical and social factors associated with early childhood development. Although previous studies have found an association between late preterm births and receipt of special education funding (Chyi et al., 2008; Lipkind et al., 2012), only the base and medical adjusted models supported this conclusion.

In general, poorer language and communication among children born late preterm is consistent with the literature. In a population-based study that examined EDI among Manitoba's children, the effect of biological vulnerability at birth, which included being born preterm, was strongest for the physical domain, followed by the language and communication domains (Santos et al., 2012). Other studies have found the late preterm population to have significantly lower scores in language at age 2 and 4 (Nepomnyaschy et al., 2012), poorer non-verbal language (Chen et al., 2014), and significantly higher risks of not meeting overall achievement in communication, language, reading and math development at age 5 (Quigley et al., 2012). Set-backs have been found to be stronger in this population at age 4 compared to age 2, and have included lower scores in language, vocabulary, math ability and reading (Nepomnyaschy et al., 2012). In contrast to our findings, Potijk et al. (2013) found that GA and SES had separate but multiplicative effects on developmental delay in all but communication and Quigley et al. (2012) found no differences in physical development at age 5.

Vulnerabilities in physical health, communication and language development in kindergarten did not seem to translate into poorer reading and numeracy achievement in the third grade. Although crude rates and unadjusted analyses in this study demonstrated poorer achievement in the third grade, social predictors demonstrated a stronger association with not meeting or approaching expectations. Others have noted this ‘catch-up’ in later grades among children born late preterm (Chyi et al., 2008). This pattern is consistent with Ahlsson et al. (2015), who postulate that socio-demographic exposures may be more important predictors of poor outcomes in this population rather than GA, at least later on in childhood. Similarly, findings by Fransoo et al (2008) demonstrated that although birth weight and GA are statistically significant predictors of later cognitive and educational outcomes, their effects are outweighed by socioeconomic influences. Although Williams (2013) found greater odds for failure for math, reading, and ELA in the first grade, their study controlled only for maternal age, maternal education, race, gender and date of birth. Similarly, Lipkind et al. (2012) found greater odds of lower math and ELA scores in third grade standards assessments, but did not control for social predictors of early childhood development, other than maternal ethnicity (Lipkind et al., 2012).

### 5.4 Effects of biological and social predictors

Exploring the role of SES was a secondary aim of this study and it was hypothesized that there would be a gradient by SES, with lower SES associated with poorer outcomes.  For many outcomes, this did not hold true in the models. No income gradients were found for ADHD, asthma, and morbidity at age 4 and 7. However, in many models, receipt of IA and the lowest income quintile were statistically significant, suggesting that low SES was associated with poorer childhood development after controlling for multiple confounders. In general, an income gradient was observed for the EDI outcomes and grade 3 reading and numeracy assessments. Several outcomes deviated from this pattern of poorer outcomes among those of low SES or on IA. For example, the middle income group (quintile 3) was significantly associated with increased odds of grade repetition (aOR=2.18) and LRTIs (aOR=1.31), and the lowest income group (quintile 1) was associated with lower odds of morbidity at age 7 compared to children from the highest income group (quintile 5).

Several variables, namely poor health status during the first of life, male sex, low income and receipt of IA, young maternal age at first birth, and involvement in CFS were statistically significant in almost all models. Social covariates were less likely to be significant predictors in the health models than in the other outcome models. Conversely, in the education models, almost all of the included social covariates were statistically significant.

For LRTIs, significant predictors included low and middle-income status, young maternal age at first birth, multiple births and poor health status during the first year of life. This was similar for asthma, with the addition of being born SGA, receipt of IA and decreased odds in families with four or more children. Factors that increased the odds of ADHD included maternal diabetes, receipt of IA, a maternal age at first birth of 18-19 and 20-24, receipt of support or protection services, and being a child in care. Maternal diabetes has been previously linked to poorer attention span at school entry (Ornoy et al., 2001). It is plausible that the association between involvement with CFS and ADHD is in part due to inadvertently picking up those with fetal alcohol spectrum disorder (FASD), as it is difficult to differentiate the reason for psychostimulant medication use in administrative data. Being born LGA and being part of a large family were associated with lower odds of ADHD. Morbidity at age 4 and 7 followed a different pattern, where significant predictors included maternal diabetes, high income, being an older mother at the time of first birth, and being a child in care or child whose family received support or protection services. Given that physician visits are largely parent-driven in the early years, it is plausible that higher income parents were more likely to seek out health care for their children. Similarly, being an older mother at first birth is often associated with higher income attainment, but can also be associated with higher risk pregnancies that may result in poorer health outcomes in the early years.

For being not ready in the language domain of the EDI, receipt of IA had the greatest association, followed by receipt of support or protections services and young maternal age at first birth. For the communication domain, variables most strongly associated with the outcome included belonging to a large family, followed by receipt of support of protection services, being born SGA, low income quintile, a maternal age at first birth of 20-24 followed by 18-19, and male sex. This was similar for being not ready in the physical domain, with the addition of maternal diabetes. These findings are consistent with the literature on the risk factors for not being ready for kindergarten, including a strong association with SES, young maternal age, and being born SGA (Santos et al., 2012). Similarly, involvement with CFS has been strongly linked to poor academic achievement, including increased vulnerability on the EDI assessments (Brownell et al., 2015). Finally, young maternal age, belonging to a large family, maternal diabetes, and involvement in child and family services were all significantly associated with increased odds of grade repetition. These associations are consistent with the notion that both biological and in particular, social risk, have negative impacts on early childhood development.

Within the BF/FF models, none of the BF/FF variables were significantly associated with the health outcomes examined, with the exception of smoking during pregnancy being significantly associated with increased odds of ADHD. This association is in line with previous studies (Ernst, Moolchan, & Robinson, 2001; Langley et al., 2005; Langley, Heron, Smith, & Thapar, 2012; Mick et al., 2001; Robinson, 2001), however there is debate to whether this association is due to direct intrauterine effects of smoking on the development of ADHD or to confounding factors (Langley et al., 2012) The BF/FF variables were more so associated with the education outcomes, in particular, smoking during pregnancy, in all but grade repetition and receipt of special education funding. Having a mother who had not graduated from high school at the time of birth or having a missing response on this screen question was associated with elevated odds of being not ready in 1+ domain, 2+ domains, the communication and physical domain, grade repetition, and not meeting or approaching expectations in grade 3 reading and numeracy. Substance use during pregnancy was associated with decreased odds of not being ready in 1+ domain and the communication domain, and being a lone parent was associated with decreased odds of not being ready in 2+ domains and not meeting or approaching expectations in reading in the third grade. These findings are counterintuitive and difficult to interpret. It may be that those affected by these risk factors did not receive the BF/FF screen, and thus, the risk is not being adequately picked up. In addition, some of these children might have been apprehended shortly after birth, and in such cases, the mothers would not receive the FF screen. Mothers who admitted to using drugs or alcohol during pregnancy may also have gone on to receive additional supports throughout their child’s early development period (e.g., FF program) that helped to mitigate the risk of poor development. Similarly, some children raised by a single parent may have other positive influences in their life, including increased interaction with other family members.

## 5.5 Relationship of findings to theoretical framework

The findings of this study fit with the life course theory and confirm the importance of the social determinants of health. The associations between social factors and early childhood development became stronger as children aged, and by the time children entered their school years, almost all social predictor variables became significant in the models. Following life course theory, examining outcomes in the late preterm population is not as simple as linking an occurrence at birth to health and development during the later stages, but also considering how this initial risk is exacerbated or mitigated by risk and protective factors (Braveman, 2014). Childhood poverty and adverse family situations, including involvement with CFS, were important variables affecting the outcomes examined. The results also confirmed that intergenerational risk, including maternal age at first birth, maternal diabetes, and maternal education attainment, also impacts the development of the child. The results of this study were congruent with the life course theory and demonstrated the rippling effects of socioeconomic adversity on early childhood development.

## 5.6 Strengths

Given the increasing interest in the late preterm population, this topic was chosen to further the evidence base on the potential long-term risks in this population, and also to consider the influence of SES, which is associated with both preterm birth and early childhood development. This is the second Canadian study to examine the development of children born late preterm, but included a much larger range of outcomes over a longer period of time. Furthermore, very few existing studies examine the influence of SES or control for it in modeling.

Because these infants were previously viewed as low risk, routine follow up poses financial and logistic implications due to a lack of data collection in some settings (Boyle, 2012). Beyond the financial implications of data collection, if poorer outcomes do exist, there is also a need to determine viable and acceptable methods of follow up given the large number of children affected. Fortunately, in Manitoba there exists ongoing efforts that facilitate this sort of follow up, including two province-wide “check-points,” the BF/FF screen and EDI assessments, as well as the existence of the Repository at MCHP, which contains linkable data on all children in Manitoba. This enabled us not only to conduct an urban population-based study with a large sample size, but also to examine a large number of outcomes and to control for numerous covariates that influence early childhood development.

There are many strengths to using administrative databases for population health research (Jutte, Roos, & Brownell, 2011). Unlike traditional longitudinal studies or survey data, the use of administrative data is relatively inexpensive, has the ability to produce findings that are generalizable and reflective of the entire population, and avoids issues of recall bias and loss to follow-up (Jutte et al., 2011). Data linkage also allows us to examine outcomes from different domains and across different sectors (Jutte et al., 2011). In this study, this allowed for the examination of both health and educational outcomes and to incorporate exposure effects over time.

Finally, removing the early term (37-38 weeks GA) population strengthened this analysis, as grouping them with the term group, which many previous studies have done, would weaken the findings. Research has shown that although the early term group performs better than the late preterm population, they are not the same as term (ACOG, 2013; Sengupta et al., 2013). Examining outcomes in this population is a direction for future research.

## 5.7 Limitations

A major limitation of this study was the exclusion of late preterm and term births that occurred to those living in rural Manitoba and those living in First Nations communities. These births were excluded because data are not available for variables measured through the BF/FF screen for women living in First Nations communities. Similarly, women living in First Nations communities are not eligible for the provincial assistance program (IA) but may instead receive assistance from federally funded programs, which are not captured in the data available at MCHP. In addition, education records for children attending First Nations schools are incomplete, so grade repetition, EDI and assessment information would have been unavailable for some of these children, all of which would have resulted in major gaps in the analysis. Additionally, findings are only generalizable to an urban population and may differ when examined in a rural or northern setting.

Secondly, because multiple births represent a significant proportion of the late preterm population, they were not excluded from the analysis. This could result in misclassification when classifying children by size for gestational age, which is an important predictor of later childhood outcomes (Hall, Jaekel, & Wolke, 2012; Lundgren & Tuvemo, 2008; Strauss, 2000). Application of Kramer growth curves for both singletons and multiples born late preterm were used to control for misclassification (Kramer et al., 2001). Given that multiples were significantly associated with increased odds of LRTIs, a sensitivity analysis was conducted to ensure that the effects were not solely due to the inclusion of multiple births.

There is also the potential for miscoding in hospital, physician visit and prescription data, which may over or underestimate differences between gestational groups on the outcomes of interest measured in the analyses. Physician visits during the childhood years can also be very parent driven, and thus may not truly reflect ill health, particularly as it relates to differences in use by SES. Because educational measures, including school readiness (EDI) and grade 3 reading assessments, are based on teacher-administered scales, they may also be subject to teacher bias. However, it is unlikely that teacher ratings would be different across different GA comparison groups. They may however differ by SES.

Several variables identified in the literature review could not be included in modeling. In particular, we were unable to adjust for race/ethnicity, immigrant status, and primary language, because those variables were not available in the databases at MCHP. Although breastfeeding has been associated with a number of positive outcomes in the early childhood period (Kramer et al., 2008; Martens, 2012), breastfeeding initiation was not adjusted for in the analyses. Though we did not adjust for mother's age, we did control for mother's age at first birth, which is often more strongly associated with SES (Jutte et al., 2010). Some medical factors around the time of birth, including medical determinants of preterm birth, were not adjusted for in the analyses. Though this may be seen as a limitation, it was thought that it was more important to control for factors related to early childhood development rather than the factors driving preterm birth, given the focus of the study.

From a methodological standpoint, future studies should examine the interaction effect of SES and GA in order to examine whether SES was a moderator of GA, and vise-versa. In addition, the inclusion of multiple variables and comparisons among the variables increases the risk of making a Type I error; that is, finding a statistically significant effect where it does not actually exist. The threat of Type I error in such cases can be reduced by using a more stringent p value (e.g., $p<0.001$). This approach was not taken in this study, as the research questions focused mainly on the differences between the late preterm and term populations. The additional variables analyzed in the models were included as covariates and for hypothesis generating, making the use of p<.05 appropriate.

Finally, with this this study and many other studies using observational data it is important to exert caution when making assumptions about causation, as results are correlational rather than causal. However, it is still important to identify associations, and at a policy level, there is still a need to highlight children born late preterm as having potential problems that should be addressed.

### 5.8 Future research and policy implications

Given increased odds of ADHD, respiratory morbidity and developmental vulnerability in the language and cognitive, communication and general knowledge, and physical health and well-being domains of the EDI, attention should be given to this population post-discharge and prior to school entry, particularly those at social disadvantage. For almost all of the avenues in which late preterm children performed poorly, those with young mothers at the time of first birth, on IA or living in low-income neighborhoods, and those involved with CFS, were at greater risk, which is consistent with the literature (Santos et al., 2012). These findings are hypothesis generating and highlight areas for future research. In particular, the strong associations found between CFS involvement and poor outcomes and the association between maternal diabetes, ADHD and poor school outcomes, deserve further examination. Biological or medical vulnerability, mainly having a high number of diagnoses in the first year of life, was also associated with increased odds of the conditions examined, particularly for those related to health. Given the noted social risk identified through modeling, the multidisciplinary guidelines from the National Perinatal Association for the management of late preterm infants (Phillips et al., 2013) should extend the long term follow-up of this population to include the screening of family risk factors, including SES. Given existing screening programs in Manitoba, such as the BF/FF screen, it is likely that many of these families are already reached through existing programs. However, there is evidence that some of the highest risk families are missed by the screen and that some families that screen at high risk refuse to participate in the FF program, which imposes problems for providing supports and services and has implications for policy and practice (Brownell et al., 2011). Given the high number of women identified in this study as not being screened and the characteristics of the women not screened, it appears that the BF/FF screen is not reaching all those who it is intended to reach. Negative experiences with the health care system and past involvement with CFS have been previously noted as perceived barriers to the uptake of prenatal care (Heaman et al., 2015). Given the high involvement with CFS in this population, fear of child apprehension may also contribute to a reluctance of women to participate in the screening and participation of the BF/FF program. Different approaches may be needed to reach these high risk women and to achieve better uptake of services and more positive outcomes.

One of the key policy implications of this study is the strong associated social risk in this population and the large role that social risks play in the development of children, especially as they age. Many of the factors leading to preterm birth, poor health, and educational outcomes are similar and intertwined. Most importantly, preterm birth itself is preventable and requires an upstream approach. Programs in Manitoba such at the Manitoba Health Baby Program have demonstrated the positive impact of improving social conditions on subsequent birth outcomes through even a minimal increase in income attainment throughout pregnancy (Brownell et al., 2015). Increasing the uptake of adequate prenatal care has also been linked to better birth outcomes (Barros, Tavares, & Rodrigues, 1996; Vintzileos, Ananth, Smulian, Scorza, & Knuppel, 2002; Van Dijk, Willems, & Stetzer, 2011).

The results of the current study suggest that the effect of preterm birth can also be modified through social factors. Programs to improve broader community and societal level disadvantage, including those aimed at improving family welfare, adequate housing, income, and employment opportunities, are critical to improving the well-being of children and are at the root of poor outcomes (Brownell et al., 2015). The provision of the FF home visiting program, for example, has been associated with a reduction in the number of children taken into care (Chartier et al., 2015). Additional risk factors for poor outcomes identified in this study, including young maternal age at first birth, low income and CFS involvement identify a subset of children born late preterm who may require more assistance, support and follow-up.

As it currently stands, there is a large gap between the BF/FF screen and the EDI, a time when this population could be screened for potential setbacks. One solution for earlier detection could be the exploration of an enhanced 18-month well-baby visit, which was introduced in Ontario in 2009. Not only is 18 months seen as a crucial time in a child's development and a time where early detection can make a difference, but also a crucial time to screen for parental and family risk and connect families with community resources (Williams, Clinton, & The Canadian Paediatric Society, 2011). It may also be the last time that a child sees their primary care provider until the child is 4 or begins school and thus, is a critical time to promote healthy development during this pivotal period and be alert to signs of difficulty, including those related to communication and language (Williams et al., 2011).

Although developmental surveillance occurs in most countries, many keep track of development with simple milestone checklists and do not recommend the use of a validated screening tool (Williams et al., 2011). The frequency and content of the well-baby visit varies widely across Canada and other developed countries. Health and developmental screening prior to age 6 ranges from a frequency of four visits in Scotland to fifteen in Sweden, the Netherlands, and the United States (Hall & Elliman, 2003). The content of these visits also vary from immunization and growth monitoring to developmental screening and anticipatory guidance (Hall & Elliman, 2003). It is difficult to assess the success of these visits within Canada, as there are currently no standardized practices or measurements for 18-month follow up across the country. Given that this is a routine visit to a child's primary care provider, it may not be associated with excessive additional costs (Brownell et al., 2011), besides additional fees to physicians. Based on a pilot examination of Ontario's program, difficulties of implementing the enhanced visit related to the time needed to complete the screen and not having adequate community supports in place when children are identified as having developmental needs. Thus, screening for difficulties in this population would not be beneficial if adequate resources were not in place. Future studies could use data from these screens to examine whether differences exist for the late preterm population at this stage and whether early detection and intervention would make a difference on outcomes. It would also be of relevance to assess the applicability of enhanced developmental screening for certain populations, such as the late preterm population, at a time where it is being explored.

Additional gaps in the literature include the costs of late preterm delivery on childhood outcomes and the incidence of late preterm birth and associated risk factors among Manitoba's Indigenous populations, who have higher rates of preterm births (Heaman et al., 2005). Examining the early childhood development of Manitoba's rural and northern late preterm children is also warranted to aid policy makers in decision making and planning towards continued early childhood development success in Manitoba.

## 5.9 Knowledge Translation

Though the findings of this study will follow a typical end-of-grant knowledge translation (KT) approach of publishing and presenting at academic conferences, the findings and process are also deserving of an integrated KT approach. Given previous discussions with policy makers from Healthy Child Manitoba, the Healthy Child Committee of Cabinet, the Winnipeg Regional Health Authority, and the Early Childhood Education Unit during the research phase on the policy relevance of this topic, targeted presentations will be given to the above noted agencies. In addition, findings should be disseminated to people on the ground, including health care professionals in neonatology, obstetrics, and pediatrics.

## 5.10 Conclusion

When examining the late preterm group as a whole, they appear to perform poorly in all avenues. However, when examining the characteristics of these children, it becomes evident that they are an at-risk group, and failing to control for social disadvantage may lead to unwarranted conclusions about the effect of prematurity at the late preterm stage. In this study, controlling for a range of medical and social factors diminished, but did not eliminate the effect of GA. Children born late preterm were more likely to have respiratory conditions, including LRTIs and asthma, as well as ADHD during the early childhood years. At school entry, children born late preterm were also more likely to be not ready for school in their physical health and well-being, language and cognitive, and communication and general knowledge development compared to those born at term. They were also more likely to repeat kindergarten and grade 1. Given that the late preterm population consists of 75% of the preterm population, or around 6% of births overall, increased morbidity in this population has implications at the population level. This study underscores the importance of not underestimating the developmental vulnerability of this population and of adequately accounting for the social differences between children born late preterm and at term. Many biologically and socially vulnerable children may already be reached through existing programs in Manitoba. Given the findings of this study, extending this reach to include additional supports for children born late preterm may be warranted.

# References

Abe, K., Shapiro-Mendoza, C. K., Hall, L. R., & Satten, G. a. (2010). Late preterm birth and risk of developing asthma. *The Journal of Pediatrics*, *157*(1), 74–8. doi:10.1016/j.jpeds.2010.01.008

Ahlsson, F., Kaijser, M., Adami, J., Lundgren, M., & Palme, M. (2015). School Performance After Preterm Birth. *Epidemiology*, *26*(1), 106–111. doi:10.1097/EDE.0000000000000171

Alyward, G. P. (1992). The relationship between environmental risk and developmental outcome. *Developmental and Behavioral Pediatrics, 13*(3), 222-229.

American College of Obstetricians and Gynecologists. (2008). ACOG committee opinion No. 404 April 2008. Late-preterm infants. *Obstetrics & Gynecology, 111*(4), 1029–1032. doi: 10.1097/AOG.0b013e31817327d0.

American College of Obstetricians and Gynecologists. (2013). *Definition of term pregnancy.* Retrieved from http://www.acog.org/-/media/Committee-Opinions/Committee-on-Obstetric-Practice/co579.pdf?dmc=1&ts=20150918T1655132709.

Amor, L. B., Chantal, S., & Bairam, A. (2012). Relationship between late preterm birth and expression of attention-deficit hyperactivity disorder in school-aged children: Clinical, neuropsychological, and neurobiochemical outcomes. *Research and Reports in Neonatology, 2*, 77-83.

Baron, I. S., Erickson, K., Ahronovich, M. D., Baker, R., & Litman, F. R. (2011). Cognitive deficit in preschoolers born late-preterm. *Early Human Development*, *87*(2), 115–119. doi:10.1016/j.earlhumdev.2010.11.010

Baron, I. S., Kerns, K. a, Müller, U., Ahronovich, M. D., & Litman, F. R. (2012). Executive functions in extremely low birth weight and late-preterm preschoolers: Effects on working memory and response inhibition. *Child Neuropsychology: A Journal on Normal and Abnormal Development in Childhood and Adolescence*, *18*(6), 586–599. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/22122351

Barros, H., Tavares, M., & Rodrigues, T. (1996). Role of prenatal care in preterm birth and low birth weight in Portugal. *Journal of Public Health Medicine, 18*(3), 321-328.

Bastek, J., Sammel, M., Pare, E., Srinicas, S., Posencheg, M., & Elovitz, M. (2008). Adverse neonatal outcomes: Examining the risks between preterm, late preterm and term infants. American Journal of Obstetrics and Gynaecology, 199(367), e1-8.

Bee, H. L., Barnard, K. E., Eyres, S. J., Gray, C. A., Hammond, M. A., Spietz, A., Snyder, C., & Clark, B. (1982). Prediction of IQ and language skill from perinatal status, child performance, family characteristics, and mother-infant interaction. *Child Development, 53*, 1134-1156.

Behrman, R. E., & Butler, A. S. (2007). *Preterm Birth: Causes, Consequences, and Prevention.* Washington, DC: National Academies Press. Committee on Understanding Premature Birth and Assuring Healthy Outcomes.

Ben-Shlomo, Y., & Kuh, D. (2002). A life-course approach to chronic disease epidemiology: Conceptual models, empirical challenges and interdisciplinary perspectives. *International Journal of Epidemiology, 31*, 285-293.

Boyle, E. M. (2012). Neonatal Outcomes Following Late Preterm Birth. *Fetal and Maternal Medicine Review*, *23*(02), 97–119. doi:10.1017/S0965539512000071

Boyle, E. M., Poulsen, G., Field, D. J., Kurinczuk, J. J., Wolke, D., Alfirevic, Z., & Quigley, M.. (2012). Effects of gestational age at birth on health outcomes at 3 and 5 years of age : population based cohort study. *BMJ, 344*(e869). doi:10.1136/bmj.e896

Bradley, R. H., & Corwyn, R. F. (2002). Socioeconomic status and child development. *Annual Review of Psychology, 53*, 371-399.

Braveman, P. (2014). What is health equity: And how does a life-course approach take us further toward it? *Maternal and Child Health Journal, 18*(2), 366-372.

Brown, H. K., Nixon Speechley, K., Macnab, J., Natale, R., & Campbell, M. K. (2014). Mild prematurity, proximal social processes, and development. *Pediatrics, 134*(3), e814-824. doi:10.1542/peds.2013-4092.

Brownell, M. D., Chartier, M., Au, W., MacWilliam, L., Shultz, J., Guenette, W., & Valdivia, J. (2015). *The educational outcomes of children in care in Manitoba.* Winnipeg, MB. Manitoba Centre for Health Policy.

Brownell, M. D., Chartier, M., Martens, P., Chateau, D., Nickel, N., Burland, E., … & Hu, M. (2015, May). *Impact of the Healthy Baby Prenatal Benefit on perianal outcomes: A PATHS Equity for Children project.* Presented at the Canadian Association of Health

Services and Policy Research Conference, Montreal, QC. Retrieved from https://www.cahspr.ca/en/presentation/55745db937dee82b15501956

Brownell, M. D., Chartier, M., Santos, R., Au, W., Roos, N. P., & Girard, D. (2011). Evaluation of a newborn screen for predicting out-of-home placement. *Child Maltreatment, 16*(4):239-49. doi: 10.1177/1077559511422942.

Brownell, M., Chartier, M., Santos, R., Ekuma, O., Au, W., Sarkar, J., MacWilliam, L., Burland, E., Koseva, I., & Guenette, W. (2012). *How Are Manitoba's Children Doing?* Winnipeg, MB. Manitoba Centre for Health Policy.

Brownell, M., Kozyrkyj, A., Roos, N., Friesen, D., Mayer, T., & Sullivan, K. (2002). Health service utilization by Manitoba children. *Canadian Journal of Public Health. 93*(suppl. 2), S57-62.Calogero, C., & Sly, P. D. (2010). *Developmental physiology: Lung function during growth and development from birth to old age.* In U. Frey & P. J. Merkus (Eds.), Paediatric Lung Function (p. 1-15). Plymouth, UK: European Respiratory Society.

Canadian Institute for Health Information. (2004). *Improving the health of Canadians.* Retrieved from https://secure.cihi.ca/free_products/IHC2004rev_e.pdf

Canadian Institute for Health Information. (2006). *Giving birth in Canada: The costs.* Retrieved from http://publications.gc.ca/collections/Collection/H118-38-2006E.pdf

Canadian Institute for Health Information. (2009). *Too Early, Too Small: A Profile of Small Babies Across Canada.* Retrieved from https://secure.cihi.ca/free_products/too_early_too_small_en.pdf.

Chan, E., & Quigley, M. A. (2014). School performance at age 7 years in late preterm and early term birth: A cohort study. *Archives of Disease in Childhood. Fetal and Neonatal Edition, 99*(6), F451-457.

Chartier, M., Brownell, M., Isaac, M., Chateau, D., Nickel, N., Martens, P., … & PATHS Equity Team Members. (2015, May). *Is the Families First Home Visiting Program effective at reducing population level health and social disparities? A PATHS equity for children project.* Presented at the Canadian Association of Health Services and Policy Research Conference, Montreal, QC. Retrieved from https://www.cahspr.ca/fr/presentation/5570545037dee8c2789dd2ee

Chauhan, S. P. (2011). Late preterm births: irreducible because E=mc2. *American Journal of Obstetrics and Gynecology, 204*(6), 459–460.

Chen, J. H., Claessens, A., & Msall, M. E. (2014). Prematurity and school readiness in a nationally representative sample of Australian children: Does typically occurring preschool moderate the relationship. *Early Human Development*, *90*(2), 73–79. doi:10.1016/j.earlhumdev.2013.09.015

Chyi, L. J., Lee, H. C., Hintz, S. R., Gould, J. B., & Sutcliffe, T. L. (2008a). School outcomes of late preterm infants: special needs and challenges for infants born at 32 to 36 weeks gestation. *The Journal of pediatrics, 153*(1), 25–31. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/18571530

Chyi, L. J., Lee, H. C., Hintz, S. R., Gould, J. B., & Sutcliffe, T. L. (2008b). School outcomes of late preterm infants: special needs and challenges for infants born at 32 to 36 weeks gestation. *The Journal of pediatrics, 153*(1), 25–31. doi:10.1016/j.jpeds.2008.01.027

Colin, A. A., Mcevoy, C., & Castile, R. G. (2010). Respiratory morbidity and lung function in preterm infants of 32 to 36 weeks' gestational age. *Pediatrics, 126*(1), 115-128.

De Jong, M., Verhoeven, M., & Van Baar, A. L. (2012). School outcome, cognitive functioning, and behaviour problems in moderate and late preterm children and adults: A review. *Seminars in Fetal Neonatal Medicine*, *17*(3), 163–9. doi:10.1016/j.siny.2012.02.003

Duncan, G. J., Brooks-Gunn, J., & Klebanov, P. K. (1994). Economic deprivation and early childhood development. *Child Development*, *65*, 296–318. doi:10.1111/1467-8624.ep9405315105

Ekeroma, A. J., Craig, E. D., Stewart, A. W., Mantell, C. D., & Mitchell, E. A. (2004). Ethnicity and birth outcome : New Zealand trends 1980 – 2001 : Part 3. Pregnancy outcomes for Pacific women, *The Australian & New Zealand Journal of Obstetrics and Gynecology, 44*(6), 541–544.

Engle, W. A. (2007). Late-preterm infants: A population at risk. *Pediatrics, 126*(2), 1390-1401. doi: 10.1542/peds.2007-2952.

Ernst, M., Moolchan, E. T., & Robinson, M. L. (2001). Behavioral and neural consequences of prenatal exposure to nicotine. *Journal of the American Academy of Child and Adolescent Psychiatry, 40*(6), 630-641.

Escobar, G., Clark, R. H., & Greene, J. D. (2006). Short-term outcomes of infants born at 35 and 36 weeks gestation: We need to ask more questions. *Seminars in Perinatology, 114*(1), 28-33.

Evans, G. W., Li, D., & Whipple, S. S. (2013). Cumulative risk and child development. *Psychological Bulletin, 139*(6), 1342-1394. doi: 10.1037/a0031808.

Fan, R. G., Portuguez, M. W., & Nunes, M. L. (2013). Cognition, behavior and social competence of preterm low birth weight children at school age. *Clinics (São Paulo, Brazil), 68*(7), 915–21. doi:10.6061/clinics/2013(07)05

Fine, A., & Kotelchuck, M. (2010). *Rethinking MCH: The life course model as an organizing framework.* U.S. Department of Health and Human Services Health Resources and Services Administration Maternal and Child Health Bureau. [Internet]. Retrieved from http:// www.hrsa.gov/ourstories/mchb75th/images/rethinkingmch.pdf.

Finlayson, G., Reimer, J., Dahl, M., Stargardter, M., & McGowan K. (2009). *The Direct Cost of Hospitalizations in Manitoba, 2005/06.* Winnipeg, MB: Manitoba Centre for Health Policy, March 2009.

Fontes, M., Fonseca, M., Camargos, P., Affonso, A.,. & Calazans, G. (2005). Asthma in children under five years of age: problems in diagnosis and in inhaled corticosteroid treatment. *Jornal Brasilerirо de Pneumologia, 31*(3), 244-253.

Fransoo, R., Roos, N. P., Martens, P. J., Heaman, M., Levin, B., & Chateau, D. (2008). How health status affects progress and performance in school: a population-based study. *Canadian Journal of Public Health, 99*(4), 344-349.

Gilbert, W. M., Nesbitt, T. S., & Danielsen, B. (2003). The cost of prematurity: quantification by gestational age and birth weight. *Journal of Obstetrics and Gynecology, 102*(3), 488-492.

Glinianaia, S. V, Ghosh, R., Rankin, J., Pearce, M. S., Parker, L., & Pless-Mulloli, T. (2013). No improvement in socioeconomic inequalities in birthweight and preterm birth over four decades: a population-based cohort study. *BMC Public Health*, *13,* 345-354. doi:10.1186/1471-2458-13-345

Government of Manitoba. (2013). *Starting early, starting strong: Manitoba's early childhood development framework*. Retrieved from http://www.gov.mb.ca/cyo/pdfs/sess_ECD_framework.pdf

Goyal, N. K., Fiks, A. G., & Lorch, S. a. (2011). Association of late-preterm birth with asthma in young children: practice-based study. *Pediatrics*, *128*(4), e830–838. doi:10.1542/peds.2011-0809

Guedeney, A., Marchand-Martin, L., Cote, S., & Larroque, B. (2012). Perinatal risk factors and social withdrawal behavior. *European Journal of Child & Adolescent Psychiatry, 21*(4), 185-192.

Guihard-Costa, A. M., & Larroche, J. C. (1992). Growth velocity of some fetal parameters. I. Brain weight and brain dimensions. *Biology of the Neonate*, *62*(5), 309–316.

Gurka, M. J., LoCasale-Crouch, J., & Blackman, J. A. (2010). Long-term cognition, achievement, socioemotional, and behavioral development of healthy late-preterm infants. *Archives of Pediatric and Adolescent Medicine, 164*(6), 525-532. doi:10.1001/archpediatrics.2010.83.

Gyamfi-Bannerman, C., Fuchs, K., Young, O., & Hoffman, M. (2011). Nonspontaneous late preterm birth: etiology and outcomes. *American Journal of Obstetrics and Gynaecology, 205*(5), 456.e1-6. doi: 10.1016/j.ajog.2011.08.007

Hall, D. M., & Elliman, D. (2003). *Health for all children.* 4th ed. Oxford: Oxford University Press.

Hall, J., Jaekel, J., & Wolke, D. (2012). Gender distinctive impacts of prematurity and small for gestational age (SGA) on age-6 attention problems. *Child and Adolescent Mental Health*, *17*(4), 238-245.

Harijan, P., & Boyle, E. M. (2012). Health outcomes in infancy and childhood of moderate and late preterm infants. *Seminars in Fetal & Neonatal Medicine*, *17*(3), 159–62. doi:10.1016/j.siny.2012.02.002

Harju, M., Keski-Nisula, L., Georgiadis, L., Raatikainen, K., Räisänen, S., & Heinonen, S. (2015). Maternal socioeconomic status and the risk of asthma among offspring. *BMC Public Health*, *15*, 1–7. doi:10.1186/s12889-015-1357-6

Harju, M., Keski-Nisula, L., Georgiadis, L., Räisänen, S., Gissler, M., & Heinonen, S. (2014). The burden of childhood asthma and late preterm and early term births. *Journal of Pediatrics*, *164*. doi:10.1016/j.jpeds.2013.09.057

Harris, M. N., Voigt, R. G., Barbaresi, W. J., Voge, G. a., Killian, J. M., Weaver, a. L., Colby, C. E., et al. (2013). ADHD and Learning Disabilities in Former Late Preterm Infants: A Population-Based Birth Cohort. *Pediatrics*, *132*(3), e630–e636. doi:10.1542/peds.2012-3588

Health Council of Canada. (2006). *Their future is now: Healthy choices for Canada's children and youth.* Retrieved from http://www.healthcouncilcanada.ca/tree/2.25-HCC_ChildHealth_EN.pdf

Heaman, M., Blanchard, J., Gupton, A., Moffat, M., & Currie, R. (2005). Risk factors for spontaneous preterm birth among Aboriginal and non-aboriginal women in Manitoba. *Paediatric and Perinatal Epidemiology, 19*(3), 181-193.

Heaman, M., Kingston, D., Helewa, M. E., Brownell, M., Derksen, S., Bogdanovic, B., McGowan, K. L., & Bailly, A. (2012). *Perinatal Services and Outcomes in Manitoba.* Winnipeg, MB. Manitoba Centre for Health Policy.

Heaman, M., Kingston, D., Chalmers, B., Sauve, R., Lee, L., & Young, D. (2013). Risk factors for preterm birth and small for gestational age births among Canadian women. *Paediatric and Perinatal Epidemiology, 27*(1), 54-61.

Heaman, M., Sword, W., Elliott, L., Moffatt, M., Helewa, M., Morris, H., … & Cook, C. (2015). Barriers and facilitators related to use of prenatal care by inner-city women: Perceptions of health care providers. *BMC Pregnancy and Childbirth, 15*(2). doi:10.1186/s12884-0431-5.

Heckman, J. (2006). *The economics of investing in children.* Retrieved from http://www.ucd.ie/geary/static/publications/policybriefings/geary_report1.pdf

Heckman, J. (2008). *The case for investing in disadvantaged young children.* Retrieved from http://heckmanequation.org/content/resource/case-investing-disadvantaged-young-children

Heinonen, K., Eriksson, J. G., Kajantie, E., Pesonen, a.-K., Barker, D. J., Osmond, C., & Raikkonen, K. (2013). Late-Preterm Birth and Lifetime Socioeconomic Attainments: The Helsinki Birth Cohort Study. *Pediatrics, 132*(4), 647–655. doi:10.1542/peds.2013-0951

Hertzman, C. (2012). Putting the concept of biological embedding in historical perspective. *Proceedings of the National Academy of Sciences, 109*(suppl. 2), 17160-17167. doi:10.1073/pnas.1202203109

Johns Hopkins School of Public Health. (2009). *The Johns Hopkins ACG System: A technical reference guide, version 9.0.* Retrieved from http://acg.jhsph.org/public-docs/ACGv9.0TechRefGuide.pdf

Johnson, S., Evans, T. a., Draper, E. S., Field, D. J., Manktelow, B. N., Marlow, N., & Matthews, R. (2015). Neurodevelopmental outcomes following late and moderate prematurity: a population-based cohort study. *Archives of Disease in Childhood - Fetal and Neonatal Edition*, *100*(4), F301-308. doi:10.1136/archdischild-2014-307684

Johnson, S., & Marlow, N. (2011). Preterm birth and child psychiatric disorders. *Pediatric Research*, *69*(5), 11-18. doi:10.1203/PDR.0b013e318212faa0.

Johnston, K., Gooch, K., Korol, E., Vo, P., Eyawo, O., Bradt, P., & Levy, A. (2014). The economic burden of prematurity in Canada. *BMC Pediatrics*, *14*(1), 93. doi:10.1186/1471-2431-14-93

Jutte, D. P., Roos, L. L., & Brownell, M. D. (2011). Administrative record linkage as a tool for public health research. *Annual Review of Public Health, 32*(1), 91-108. doi: 10.1146/annurev-publhealth-031210-100700.

Jutte, D. P., Roos, N. P., Brownell, M. D., Briggs, G., MacWilliam, L., & Roos, L. L. (2010). The ripples of adolescent motherhood: Social, educational, and medical outcomes for children of teen and prior teen mothers. *Academic Pediatrics, 10*(5), 293-301.

Kapellou, O., Counsell, S. J., Kennea, N., Dyet, L., Saeed, N., Stark, J., … & Edwards A. D. (2006). Abnormal cortical development after premature birth shown by altered allometric scaling of brain growth. *PLoS Med,3*(8), e265.

Kershaw, P., Warburton, B., Anderson, L., Hertzman, C., Irwin, L., & Forer, B. (2010). The economic costs of early vulnerability in Canada. *Canadian Journal of Public Health, 101*(suppl.3), S8-S12.

Kerstjens, J. M., De Winter, Andrea, F., Bocca-Tjeertes, I. F., Ten Vergert, E. M., Reijneveld, S. A., & Bos, A. F. (2011). Developmental delay in moderately preterm-born children at school entry. *Journal of Pediatrics*, *159*(1), 92–98.

Kinney, H. C. (2006). The near-term (late preterm) human brain and risk for periventricular leukomalacia: A review. *Seminars in Perinatology, 30*(2), 81-88.

Kotecha, S. J., Dunstan, F. D., & Kotecha, S. (2012). Long term respiratory outcomes of late preterm-born infants. *Seminars in Fetal & Neonatal Medicine*, *17*(2), 77–81. doi:10.1016/j.siny.2012.01.004

Kramer, M. (2009). Late preterm birth: Appreciable risks, rising incidence. *Pediatrics, 154(*2), 159-160.

Kramer, M., Aboud, F., Mironova, E., Vanilovich, I., Platt, R., Matush, L., … & Promotion of Breastfeeding Intervention Trial (PROBIT) Study Group. (2008). Breastfeeding and child cognitive development: New evidence from a large randomized trial. *JAMA Psychiatry, 65*(5), 578-584. doi:10.1001/archpsyc.65.5.578.

Kramer, M. S., Seguin, L., Lydon, J., & Goulet, L. (2000). Socio-economic disparities in pregnancy outcome: Why do the poor fare so poorly? *Paediatric and Perinatal Epidemiology, 14(*3), 194–210.

Krieger, N., Chen, J. T., Coull, B. A., & Selby, J. V. (2005). Lifetime socioeconomic position and twins' health: An analysis of 308 pairs of United States women twins. *PLoS Medicine, 2*(7), e162.

Kugelman, A., & Colin, A. A. (2013). Late preterm infants: Near term but still in a critical developmental time period. *Pediatrics, 132*(4), 741-751. doi: 10.1542/peds.2013-1131.

Kuh, D., Ben-Shlomo, Y., Lynch, J., Hallqvist, J., & Power, C. (2003). Life course epidemiology. *Journal of Epidemiology and Community Health, 57*(10), 778-783.

Langley, K., Rice, F., van den Bree, M. B., & Thapar, A. (2005). Maternal smoking during pregnancy as an environmental risk factor for attention deficit hyperactivity disorder behavior. A review. *Minerva Pediatrica, 57*(6), 359-371.

Langley, K., Heron, J., Smith, G. D., & Thapar, A. (2012). Maternal and paternal smoking during pregnancy and risk of ADHD symptoms in offspring: Testing for intrauterine effects. *American Journal of Epidemiology, 176*(3), 261-268.

Langston, C., Kida, K., Reed, M., & Thurlbeck, W. M. (1984). Human lung growth in late gestation and in the neonate. *The American Review of Respiratory Disease, 129*(4), 607-613.

Lawlor, D., Mortenson, L., & Nybo Anderson, A. M. (2011). Mechanisms underlying the associations of maternal age with adverse perinatal outcomes: a sibling study of 264 695 Danish women and their firstborn offspring. *International Journal of Epidemiology, 40*(5), 1205-1214.

Lindstrom, K., Lindblad, F., & Hjern, A. (2011). Preterm birth and attention-deficit/hyperactivity disorder in schoolchildren. *Pediatrics, 127*(5), 858-865.

Lipkind, H. S., Slopen, M. E., Pfeiffer, M. R., & McVeigh, K. H. (2012). School-age outcomes of late preterm infants in New York City. *American Journal of Obstetrics and Gynecology, 206*(3), 222.e1–6. doi:10.1016/j.ajog.2012.01.007

Loftin, R., Habli, M., Snyder, C., Cormier, C., Lewis, D., & DeFranco, E. (2010). Late preterm birth. *Reviews in Obstetrics and Gynecology, 3*(1), 10–19. doi:10.3909/riog0098

Lundgren, E. M., & Tuvemo, T. (2008). Effects of being born small for gestational age on long-term intellectual performance. *Clinical Endocrinology & Metabolism, 22*(3), 477-488. doi: 10.1016/j.beem.2008.01.014.Machado, L. C., Passini Júnior, R., & Rodrigues Machado Rosa, I. (2014). Late prematurity: A systematic review. *Jornal de Pediatria, 90*(3), 221–231. doi:10.1016/j.jped.2013.08.012

Madsen, M., Nybo Anderson, A., Christensen, K., Andersen, P., & Osler, K. (2010). Does educational status impact adult mortality in Denmark? A twin approach. *International Journal of Epidemiology, 172*(2), 225-234.

Martens, P. J. (2012). What do Kramer's baby-friendly hospital initiative PROBIT studies tell us? A review of a decade of research. *Journal of Human Lactation*, *28*(3), 335-342. doi:10.1177/0890334412438264.

McGowan, J. E., Alderdice, F. a, Doran, J., Holmes, V. a, Jenkins, J., Craig, S., & Johnston, L. (2012). Impact of neonatal intensive care on late preterm infants: developmental outcomes at 3 years. *Pediatrics*, *130*(5), e1105–12. doi:10.1542/peds.2012-0745

McGowan, J. E., Alderdice, F., Holmes, V., & Johnston, L. (2011). Early childhood development of late-preterm infants: a systematic review. *Pediatrics*, *127*(6), 1111–1124. doi:10.1542/peds.2010-2257

Melville, J. M., & Moss, T. J. (2013). The immune consequences of preterm birth. *Frontiers in Neuroscience, 7,* 79. doi: 10.3389/fnins.2013.00079.

Mishra, G. D., Cooper, R., & Kuh, D. (2010). A life course approach to reproductive health: Theory and methods. *Maturitas, 65*(2), 92-97.

Mick, E., Biederman, J., Faraone, S. V., Sayer, J., & Kleinman, S. (2002). Case-control study of attention-deficit hyperactivity disorder and maternal smoking, alcohol use, and drug use during pregnancy. *Journal of the American Academy of Child and Adolescent Psychiatry, 41*(4), 378-385.

Milberger, S., Biederman, J., Faraone, S. V., Chen, L., & Jones. (1996). Is maternal smoking during pregnancy a risk factors for attention deficit hyperactivity disorder in children? *American Journal of Psychiatry, 153*(9), 1138-1142.

Moreira, R. S., Magalhães, L. C., & Alves, C. R. L. (2013). Effect of preterm birth on motor development, behavior, and school performance of school-age children: a systematic review. *Jornal de Pediatria (Versão em Português), 90*(2), 119–134. doi:10.1016/j.jpedp.2013.05.009

Morse, S. B., Zheng, H., Tang, Y., & Roth, J. (2009). Early school-age outcomes of late preterm infants. *Pediatrics*, *123*(4), e622–9. doi:10.1542/peds.2008-1405

Mortensen, L. H. (2013). Socioeconomic inequality in birth weight and gestational age in Denmark 1996-2007: Using a family-based approach to explore alternative explanations. *Social Science and Medicine, 76*, 1–7. doi:10.1016/j.socscimed.2012.08.021

Moster, D., Lie, R. T., & Markestad, T. (2008). Long-Term Medical and Social Consequences of Preterm Birth. *The New England Journal of Medicine, 359*(3), 262-273. doi:10.1056/NEJMoa0706475

National Perinatal Association. (2012). *Multidisciplinary guidelines for the care of late preterm infants.* Retrieved from http://www.nationalperinatal.org/lptguidelines/pdf/NPALatePretermGuidelines-11-12.pdf

Nepomnyaschy, L., Hegyi, T., Ostfeld, B. M., & Reichman, N. E. (2012). Developmental outcomes of late-preterm infants at 2 and 4 years. *Maternal and Child Health Journal*, *16*(8), 1612–24. doi:10.1007/s10995-011-0853-2

Odd, D., Evans, D., & Emond, A. (2013). Preterm Birth, Age at School Entry and Educational Performance. *PLoS ONE, 8*(10), 1–6. doi:10.1371/journal.pone.0076615

Ornoy, A., Ratzon, N., Greenbaum, C., Wolf, A., & Dulitzky, M. (2001). School-age children born to diabetic mothers and to mothers with gestational diabetes exhibit a high rate of inattention and fine and gross motor impairment. *JPEM, 14*(suppl. 1), 681-689.

Petrini, J., Dias, T., McCormick, M., Massolo, M., Green, N., & Escobar, G. (2009). Increased risk of adverse neurological development for late preterm infants. *The Journal of Pediatrics, 154*(2), 169-176.e3

Phillips, R., Goldstein, M., Hougland, K., Nandyal, R., Pizzica, A., Santa-Donato, A., … & Yost, E. (2013). Multidisciplinary guidelines for the care of late preterm infants. *Journal of Perinatology, 33*, S5-S22. doi:10.1038/jp.2013.53.

Pike, K. C., & Lucas, J. S. (2014). Respiratory consequences of preterm birth. *Pediatric Respiratory Reviews*. doi:10.1111/j.1440-1681.2006.04359.x

Popli, G., Gladwell, D., & Tsychiya, A. (2013). Estimating the critical and sensitive periods of investment in early childhood: A methodological note. *Social Science & Medicine, 97*, 316-324.

Potijk, M. R., Kerstjens, J. M., Bos, A. F., Reijneveld, S. a., & De Winter, A. F. (2013). Developmental delay in moderately preterm-born children with low socioeconomic status: Risks multiply. *Journal of Pediatrics*, *163*(5), 1289–1295. doi:10.1016/j.jpeds.2013.07.001

Poulsen, G., Wolke, D., Kurinczuk, J. J., Boyle, E. M., Field, D., Alfirevic, Z., & Quigley, M. A. (2013). Gestational age and cognitive ability in early childhood: A population-based cohort study. *Paediatric and Perinatal Epidemiology, 27*(4), 371-379. doi:10.1111/ppe.12058.

Public Health Advisory Committee. (2010). *The best start in life: Achieving effective action on child health and wellbeing.* Wellington: Ministry of Health.

Public Health Agency of Canada. (2008). *Canadian perinatal health report: 2008 edition.* Retrieved from http://www.phac-aspc.gc.ca/publicat/2008/cphr-rspc/pdf/cphr-rspc08-eng.pdf

Quigley, M. A., Poulsen, G., Boyle, E., Wolke, D., Field, D., Alfirevic, Z., & Zurinczuk, J. J. (2012). Early term and late preterm births are associated with poorer school performance at age 5 years: A cohort study. *Archives of Disease in Childhood. Fetal and Neonatal Edition, 97*(3), F167-173. doi:10.1136/archdischild-2011-300888.

Raju, T. N. K. (2006). The problem of late-preterm (near-term) births: a workshop summary. *Pediatric Research, 60*(6), 775-776.

Raju, T. N. K. (2013). Moderately preterm, late preterm and early term infant: Research needs. *Clinical Perinatology, 40*(4). doi:10.1015/j.clp.2013.07.010.

Raju, T. N. K., Higgins, R. D., Stark, A. R., & Leveno, K. J. (2006). Optimizing care and outcome for late-preterm (near-term) infants: a summary of the workshop sponsored by the National Institute of Child Health and Human Development. *Pediatrics, 118*(3), 1207–14. doi:10.1542/peds.2006-0018

Reichman, N., Teitler, J., & Moullin, S. (2015). Late-preterm birth and neonatal morbidities: Population-level and within-family estimates. *Annals of Epidemiology, 25*(2), 126-132.

Rogers, C. E., Lenze, S. N., & Luby, J. L. (2013). Late preterm birth, maternal depression, and risk of preschool psychiatric disorders. *Journal of the American Academy of Child and Adolescent Psychiatry, 52*(3), 309-318. doi:10.1016/j.jaac.2012.12.005.

Rothman, K. J., Greenland, S., & Lash, T. L. (2008). *Modern epidemiology.* 3rd edn. Philadelphia: Lippincott Williams & Wilkins.

Rowland, A. S., Lesesne, C. A., & Abramowitz, A. J. (2002). The epidemiology of attention-deficit/hyperactivity disorder (ADHD): A public health view. *Mental Retardation and Developmental Disabilities Research Reviews, 8*(3), 162-170.

Ruth, C. (2010). *The influence of socioeconomic status on morbidity in late preterm infants (master's thesis).* University of Manitoba, Winnipeg, MB.

Ruth, C., Hildes-Ripstein, E., & Brownell, M. (2014). Early term infants, length of birth stay and neonatal readmission for jaundice. *Pediatrics & Child Health, 19*(7), 353-354.

Ruth, C., Roos, N., Hildes-Ripstein, E., & Brownell, M. (2012). The influence of gestational age and socioeconomic status on neonatal outcomes in late preterm and early term gestation: a population based study. *BMC Pregnancy and Childbirth, 12*(1), 62. doi:10.1186/1471-2393-12-62

Safi, M., & Bird, M. J. (2015). The burden of childhood asthma and late preterm and early term births. *Pediatrics, 134*(4), S163. doi: 10.1542/peds.2014-1817ZZ

Sameroff, A. J. & Chandler, M. J. (1975). *Reproductive risk and the continuum of caretaker casualty.* In F. D. Horowitz (Ed.), Review of child development research (Vol. 4). Chicago: University of Chicago Press.

Santos, I. S., Matijasevich, A., Domingues, M. R., Barros, A. J. D., Victora, C. G., & Barros, F. C. (2009). Late preterm birth is a risk factor for growth faltering in early childhood: a cohort study. *BMC Pediatrics, 9*, 71. doi:10.1186/1471-2431-9-71

Santos, R. (November 2009). *EDI in Manitoba: Promoting best outcomes for Manitoba's children through evidence-based decision-making.* Presented at the Pan-Canadian Conference on Population Level Measurement of Children's Development, Winnipeg, MB.

Santos, R., Brownell, M., Ekuma, O., Mayer, T., & Soodeen, R. (2012). *The Early Development Instrument (EDI) in Manitoba: Linking Socioeconomic Adversity and Biological Vulnerability at Birth to Children's Outcomes at Age 5.* Winnipeg, MB: Manitoba Centre for Health Policy.

Sengupta, S., Carrion, V., Shelton, J., Wynn, R. J., Ryan, R. M., Singhal, K., & Lakshminrushimha, S. (2013). Adverse neonatal outcomes associated with early-term birth. *JAMA Pediatrics, 167*(11), 1053-1059. doi:10.1001/jamapediatrics.2013.2581.

Shah, P. E., Robbins, N., Coelho, R. B., & Poehlmann, J. (2013). The paradox of prematurity: The behavioral vulnerability of late preterm infants and the cognitive susceptibility of very preterm infants at 36 months post-term. *Infant behavior & development, 36*(1), 50–62. doi:10.1016/j.infbeh.2012.11.003

Sigman, M., Cohen, S. E., & Forsythe, A. B. (1981). *The relation of early infant measures to later development*, in Friedman S. L., Sigman M (eds): Preterm birth and psychological development. New york, Academic Press.

Spencer, N. (2004). The effect of income inequality and macro-level social policy on infant mortality and low birthweight in developed countries – a preliminary systematic review, *Child: Care, Health and Development*, 30(6), 699–709.

Statistics Canada. (2009). *CANSIM Tables.* Retrieved from http://www.statcan.gc.ca/start-debut-eng.html.

Stern, D. A., Morgan, W. J., Wright, A. L., Guerra, S., & Martinez, F. D. (2007). Poor airway function in early infancy and lung function by age 22 years: A non-selective longitudinal cohort study. *The Lancet, 370*(9589), 758-764.

Strauss, R. S. (2000). Adult functional outcomes of those born small for gestational age. Twenty-six-year follow-up of the 1970 British Birth Cohort. *JAMA, 283*(5), 625-632. doi:10.1001/jama.283.5.625.

Talge, N. M., Holzman, C., Wang, J., Lucia, V., Gardiner, J., & Breslau, N. (2010). Late-preterm birth and its association with cognitive and socioemotional outcomes at 6 years of age. *Pediatrics, 126*(6), 1124–31. doi:10.1542/peds.2010-1536

Teune, M., van Wassenaer, A., van Dommelen, P., Mol, B., Opmeer, B. (2011). Perinatal risk indicators for long-term neurological morbidity among preterm neonates. *American Journal of Obstetrics and Gynecology, 204*(5), 396-410.

Van Dijk, J., Anderko, L., & Stetzer, F. (2011). The impact of prenatal care coordination on birth outcomes. *Journal of Obstetric, Gynecologic, & Neonatal Nursing, 40*(1), 98-109.

Vintzileos, A. M., Ananth, C. V., Smulian, J. C., Scorza, W. E., & Knuppel, R. (2002). The impact of prenatal care in the United States on preterm births in the presence and absence of antenatal high-risk conditions. *American Journal of Obstetrics and Gynecology, 187*(5), 1254-1258.

Vogue, G. A., Katusic, S. K., Qin, R., & Juhn, Y. J. (2015). Risk of Asthma in Former Late Preterm Infants: A Propensity Score Approach. *Journal of Allergy and Clinical Immunology, In Press*. doi:10.1016/j.jaci.2010.12.327

Voigt, B., Pietz, J., Pauen, S., Kliegel, M., & Reuner, G. (2012). Cognitive development in very vs. moderately to late preterm and full-term children: can effortful control account for group differences in toddlerhood? *Early human development*, *88*(5), 307–13. doi:10.1016/j.earlhumdev.2011.09.001

Wang, M., Dorer, D., Fleming, M., & Catlin, E. (2004). Clinical outcomes of near-term infants. Pediatrics, 114, 372-376.Whyte, R. K. (2010). Safe discharge of the late preterm infant. *Pediatrics & Child Health, 15*(10), 655-660.

Werner, E., Simonian, B. S., Bierman, J. M. (1967). Cumulative effect of perinatal complications and deprived environment on physical, intellectual, and social development of preschool children. *Pediatrics, 39*, 490-505.

Whyte, R. K., & Canadian Paediatric Society, Fetus and Newborn Committee. (2010). Safe discharge of the late preterm infant. *Pediatrics & Child Health, 15*(10), 655-660.

Williams, R., Clinton, J., & The Canadian Paediatric Society. (2011). Getting it right at 18 months: In support of an enhanced well-baby visit. *Paediatrics & Child Health, 16*(10), 647-650.

Williams, B. L., Dunlop, a. L., Kramer, M., Dever, B. V., Hogue, C., & Jain, L. (2013). Perinatal Origins of First-Grade Academic Failure: Role of Prematurity and Maternal Factors. *Pediatrics, 131*(4), 693–700. doi:10.1542/peds.2012-1408

Winnipeg Regional Health Authority. (2010). *Taking care of baby*. Retrieved from http://www.wrha.mb.ca/wave/2010/12/care-baby.php

Winnipeg Regional Health Authority. (2013). *Indicator: Preterm birth.* Retrieved from http://www.wrha.mb.ca/about/healthequity/files/32%20Preterm%20Birth.pdf

Woolfenden, S., Goldfeld, S., Raman, S., Eapen, V., Kemp, L., & Williams, K. (2013). Inequality in child health: The importance of early childhood development. *Journal of Pediatrics and Child Health, 49*(9), E365-E369.

World Health Organization. (2012). *Born too soon: The global action report on preterm birth.* Retrieved from http://whqlibdoc.who.int/publications/2012/9789241503433_eng.pdf

Woythaler, M. A., McCormick, M. C., & Smith, V. C. (2011). Late preterm infants have worse 24-month neurodevelopmental outcomes than term infants. *Pediatrics, 127*(3), e622-629. doi:10.1542/peds.2009-3598.

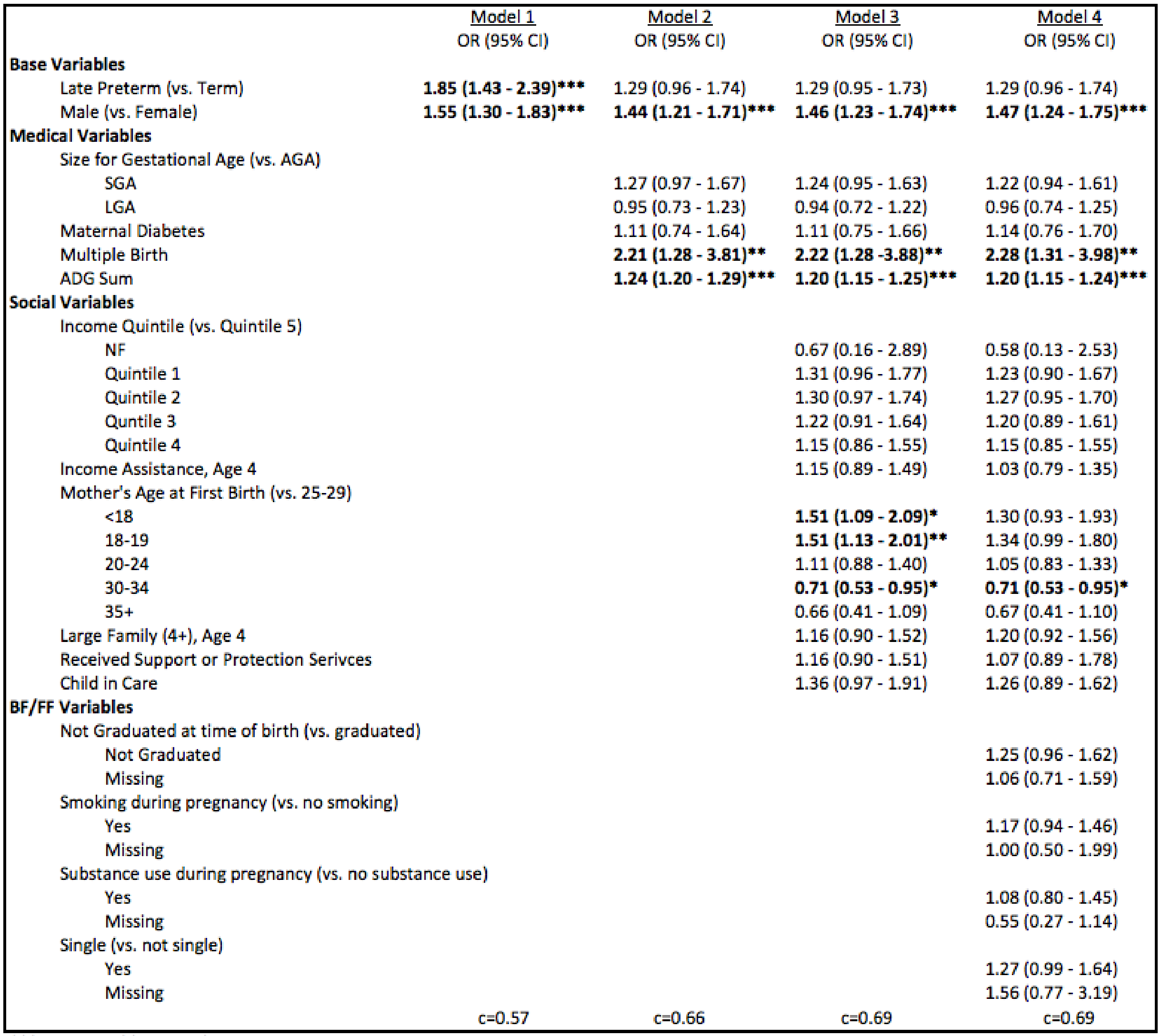
# Appendix A

Table A1: ICD codes used for significant Congenital Anomalies (CAs)

| Significant Congenital Anomalies | |
|---|---|
| ICD-9 codes: | 270-273; 740-742; 7430, 7432-7437; 7440, 7444; 7450-7454, 7456-7459; 746; 7471-7475, 7477-7479; 7480, 7482-7489; 74900, 74901, 74903, 74904, 7492; 751, 758; 7590-7598; 7503, 7505, 7506; 7530, 7531; 7560, 7565-7567, 75683, 7571; 32725; 4253; 2775. |
| ICD-10 codes: | E70-74, E76-83, E85, E88-90; Q0, Q20, Q210, Q212-214, Q218, Q22-24, Q251-259, Q26, Q271-274; Q278-29; Q28; Q300-301; Q31-37, 39-45; Q50-51, Q520, Q521; Q522-523; Q39-45, Q50-51, Q520-524, Q526-529; Q56, Q60-64; Q71-75, Q77-78, Q790, Q792-94, Q798, Q80-81; Q820-824; Q85-89, Q9. |

# Appendix B

Table B1: Logistic Regression Models of Lower Respiratory Tract Infections with BF/FF Variables (n=22,471)

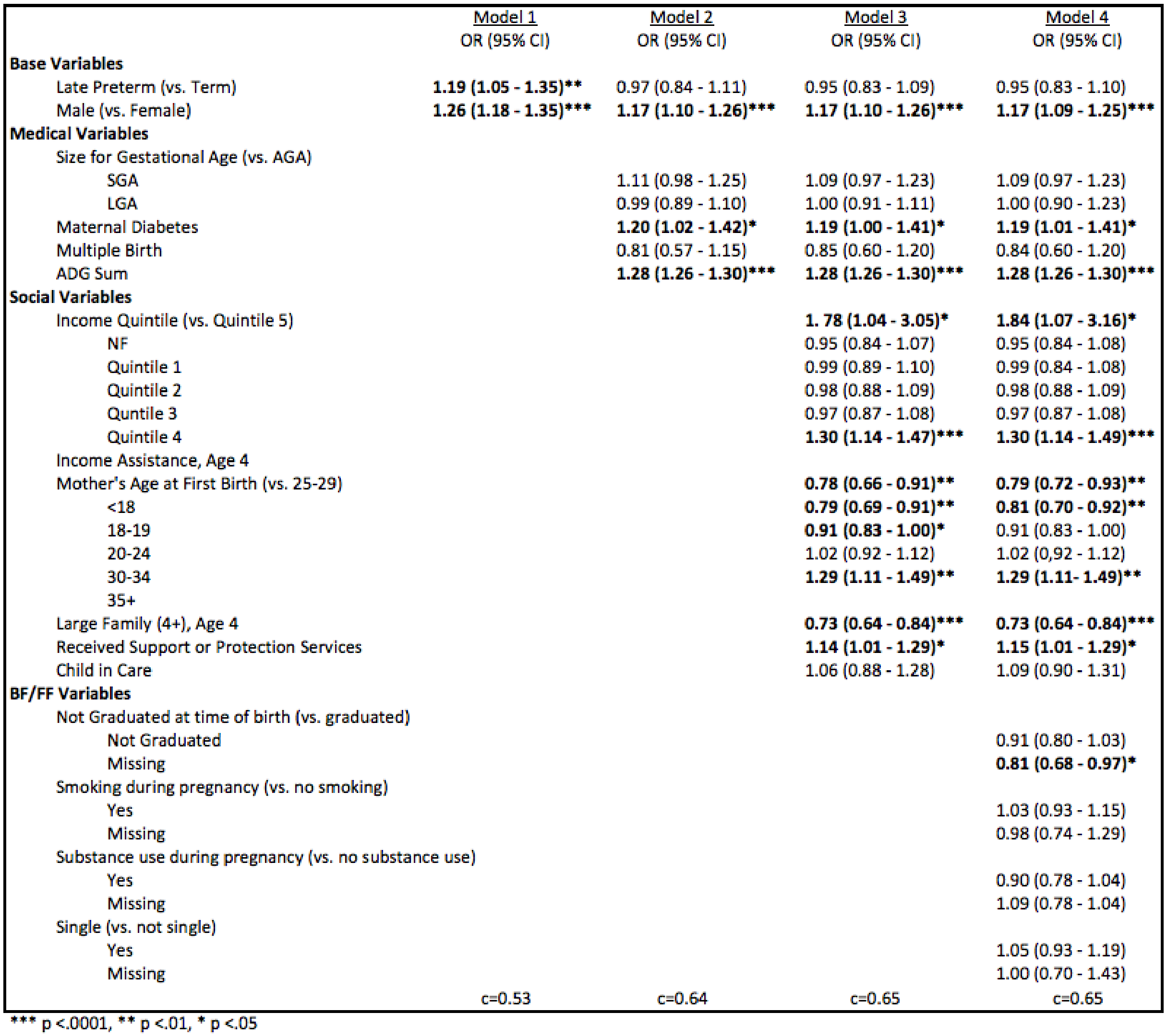


| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) | Model 4<br>OR (95% CI) |
|---|---|---|---|---|
| **Base Variables** | | | | |
| Late Preterm (vs. Term) | **1.85 (1.43 - 2.39)*** | 1.29 (0.96 - 1.74) | 1.29 (0.95 - 1.73) | 1.29 (0.96 - 1.74) |
| Male (vs. Female) | **1.55 (1.30 - 1.83)*** | **1.44 (1.21 - 1.71)*** | **1.46 (1.23 - 1.74)*** | **1.47 (1.24 - 1.75)*** |
| **Medical Variables** | | | | |
| Size for Gestational Age (vs. AGA) | | | | |
| SGA | | 1.27 (0.97 - 1.67) | 1.24 (0.95 - 1.63) | 1.22 (0.94 - 1.61) |
| LGA | | 0.95 (0.73 - 1.23) | 0.94 (0.72 - 1.22) | 0.96 (0.74 - 1.25) |
| Maternal Diabetes | | 1.11 (0.74 - 1.64) | 1.11 (0.75 - 1.66) | 1.14 (0.76 - 1.70) |
| Multiple Birth | | **2.21 (1.28 - 3.81)** | **2.22 (1.28 -3.88)** | **2.28 (1.31 - 3.98)** |
| ADG Sum | | **1.24 (1.20 - 1.29)*** | **1.20 (1.15 - 1.25)*** | **1.20 (1.15 - 1.24)*** |
| **Social Variables** | | | | |
| Income Quintile (vs. Quintile 5) | | | | |
| NF | | | 0.67 (0.16 - 2.89) | 0.58 (0.13 - 2.53) |
| Quintile 1 | | | 1.31 (0.96 - 1.77) | 1.23 (0.90 - 1.67) |
| Quintile 2 | | | 1.30 (0.97 - 1.74) | 1.27 (0.95 - 1.70) |
| Quntile 3 | | | 1.22 (0.91 - 1.64) | 1.20 (0.89 - 1.61) |
| Quintile 4 | | | 1.15 (0.86 - 1.55) | 1.15 (0.85 - 1.55) |
| Income Assistance, Age 4 | | | 1.15 (0.89 - 1.49) | 1.03 (0.79 - 1.35) |
| Mother's Age at First Birth (vs. 25-29) | | | | |
| <18 | | | **1.51 (1.09 - 2.09)*** | 1.30 (0.93 - 1.93) |
| 18-19 | | | **1.51 (1.13 - 2.01)** | 1.34 (0.99 - 1.80) |
| 20-24 | | | 1.11 (0.88 - 1.40) | 1.05 (0.83 - 1.33) |
| 30-34 | | | **0.71 (0.53 - 0.95)*** | **0.71 (0.53 - 0.95)*** |
| 35+ | | | 0.66 (0.41 - 1.09) | 0.67 (0.41 - 1.10) |
| Large Family (4+), Age 4 | | | 1.16 (0.90 - 1.52) | 1.20 (0.92 - 1.56) |
| Received Support or Protection Serivces | | | 1.16 (0.90 - 1.51) | 1.07 (0.89 - 1.78) |
| Child in Care | | | 1.36 (0.97 - 1.91) | 1.26 (0.89 - 1.62) |
| **BF/FF Variables** | | | | |
| Not Graduated at time of birth (vs. graduated) | | | | |
| Not Graduated | | | | 1.25 (0.96 - 1.62) |
| Missing | | | | 1.06 (0.71 - 1.59) |
| Smoking during pregnancy (vs. no smoking) | | | | |
| Yes | | | | 1.17 (0.94 - 1.46) |
| Missing | | | | 1.00 (0.50 - 1.99) |
| Substance use during pregnancy (vs. no substance use) | | | | |
| Yes | | | | 1.08 (0.80 - 1.45) |
| Missing | | | | 0.55 (0.27 - 1.14) |
| Single (vs. not single) | | | | |
| Yes | | | | 1.27 (0.99 - 1.64) |
| Missing | | | | 1.56 (0.77 - 3.19) |
| | c=0.57 | c=0.66 | c=0.69 | c=0.69 |

*** p <.0001, ** p <.01, * p <.05

Table B2: Logistic Regression Models of Morbidity at Age 4 with BF/FF Variables

(n=22,471)



| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) | Model 4<br>OR (95% CI) |
|---|---|---|---|---|
| **Base Variables** | | | | |
| Late Preterm (vs. Term) | **1.19 (1.05 - 1.35)**** | 0.97 (0.84 - 1.11) | 0.95 (0.83 - 1.09) | 0.95 (0.83 - 1.10) |
| Male (vs. Female) | **1.26 (1.18 - 1.35)***** | **1.17 (1.10 - 1.26)***** | **1.17 (1.10 - 1.26)***** | **1.17 (1.09 - 1.25)***** |
| **Medical Variables** | | | | |
| Size for Gestational Age (vs. AGA) | | | | |
| SGA | | 1.11 (0.98 - 1.25) | 1.09 (0.97 - 1.23) | 1.09 (0.97 - 1.23) |
| LGA | | 0.99 (0.89 - 1.10) | 1.00 (0.91 - 1.11) | 1.00 (0.90 - 1.23) |
| Maternal Diabetes | | **1.20 (1.02 - 1.42)*** | **1.19 (1.00 - 1.41)*** | **1.19 (1.01 - 1.41)*** |
| Multiple Birth | | 0.81 (0.57 - 1.15) | 0.85 (0.60 - 1.20) | 0.84 (0.60 - 1.20) |
| ADG Sum | | **1.28 (1.26 - 1.30)***** | **1.28 (1.26 - 1.30)***** | **1.28 (1.26 - 1.30)***** |
| **Social Variables** | | | | |
| Income Quintile (vs. Quintile 5) | | | **1. 78 (1.04 - 3.05)*** | **1.84 (1.07 - 3.16)*** |
| NF | | | 0.95 (0.84 - 1.07) | 0.95 (0.84 - 1.08) |
| Quintile 1 | | | 0.99 (0.89 - 1.10) | 0.99 (0.84 - 1.08) |
| Quintile 2 | | | 0.98 (0.88 - 1.09) | 0.98 (0.88 - 1.09) |
| Quntile 3 | | | 0.97 (0.87 - 1.08) | 0.97 (0.87 - 1.08) |
| Quintile 4 | | | **1.30 (1.14 - 1.47)***** | **1.30 (1.14 - 1.49)***** |
| Income Assistance, Age 4 | | | | |
| Mother's Age at First Birth (vs. 25-29) | | | **0.78 (0.66 - 0.91)**** | **0.79 (0.72 - 0.93)**** |
| <18 | | | **0.79 (0.69 - 0.91)**** | **0.81 (0.70 - 0.92)**** |
| 18-19 | | | **0.91 (0.83 - 1.00)*** | 0.91 (0.83 - 1.00) |
| 20-24 | | | 1.02 (0.92 - 1.12) | 1.02 (0,92 - 1.12) |
| 30-34 | | | **1.29 (1.11 - 1.49)**** | **1.29 (1.11- 1.49)**** |
| 35+ | | | | |
| Large Family (4+), Age 4 | | | **0.73 (0.64 - 0.84)***** | **0.73 (0.64 - 0.84)***** |
| Received Support or Protection Services | | | **1.14 (1.01 - 1.29)*** | **1.15 (1.01 - 1.29)*** |
| Child in Care | | | 1.06 (0.88 - 1.28) | 1.09 (0.90 - 1.31) |
| **BF/FF Variables** | | | | |
| Not Graduated at time of birth (vs. graduated) | | | | |
| Not Graduated | | | | 0.91 (0.80 - 1.03) |
| Missing | | | | **0.81 (0.68 - 0.97)*** |
| Smoking during pregnancy (vs. no smoking) | | | | |
| Yes | | | | 1.03 (0.93 - 1.15) |
| Missing | | | | 0.98 (0.74 - 1.29) |
| Substance use during pregnancy (vs. no substance use) | | | | |
| Yes | | | | 0.90 (0.78 - 1.04) |
| Missing | | | | 1.09 (0.78 - 1.04) |
| Single (vs. not single) | | | | |
| Yes | | | | 1.05 (0.93 - 1.19) |
| Missing | | | | 1.00 (0.70 - 1.43) |
| | c=0.53 | c=0.64 | c=0.65 | c=0.65 |

*** p <.0001, ** p <.01, * p <.05

Table B3: Logistic Regression models of Asthma at ages 6 to 8 with BF/FF variables (n=22,471)

| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) | Model 4<br>OR (95% CI) |
|---|---|---|---|---|
| **Base Variables** | | | | |
| Late Preterm (vs. Term) | **1.33 (1.17 - 1.52)*** | **1.15 (1.00 - 1.33)*** | 1.15 (1.00 - 1.32) | **1.15 (1.00 - 1.33)*** |
| Male (vs. Female) | **1.41 (1.32 - 1.52)***** | **1.35 (1.26 - 1.46)***** | **1.36 (1.26 - 1.46)***** | **1.36 (1.26 - 1.46)***** |
| **Medical Variables** | | | | |
| Size for Gestational Age (vs. AGA) | | | | |
| SGA | | **1.20 (1.06 - 1.35)**** | **1.18 (1.05 - 1.34)**** | **1.18 (1.05 - 1.34)**** |
| LGA | | 0.90 (0.81 - 1.01) | 0.91 (0.82 - 1.02) | 0.91 (0.82 - 1.02) |
| Maternal Diabetes | | 1.07 (0.89 - 1.28) | 1.15 (0.83 - 1.59) | 1.05 (0.88 - 1.26) |
| Multiple Birth | | 1.08 (0.78 - 1.50) | 1.15 (0.83 - 1.59) | 1.16 (0.84 - 1.61) |
| ADG Sum | | **1.16 (1.14 - 1.18)***** | **1.15 (1.13 - 1.18)***** | **1.15 (1.33 - 1.17)***** |
| **Social Variables** | | | | |
| Income Quintile (vs. Quintile 5) | | | | |
| NF | | | 0.74 (0.36 - 1.53) | 0.74 (0.36 - 1.53) |
| Quintile 1 | | | **1.18 (1.04 - 1.33)*** | **1.17 (1.03 - 1.33)*** |
| Quintile 2 | | | 1.10 (0.98 - 1.24) | 1.10 (0.98 - 1.23) |
| Quntile 3 | | | 1.03 (0.92 - 1.15) | 1.02 (0.91 - 1.15) |
| Quintile 4 | | | 1.03 (0.92 - 1.15) | 1.03 (0.92 - 1.15) |
| Income Assistance, Age 4 | | | **1.35 (1.17 - 1.54)***** | **1.32 (1.15 - 1.52)**** |
| Mother's Age at First Birth (vs. 25-29) | | | | |
| <18 | | | 0.97 (0.82 - 1.14) | 0.95 (0.80 - 1.13) |
| 18-19 | | | **0.85 (0.74 - 0.98)*** | **0.84 (0.73 - 0.97)*** |
| 20-24 | | | 1.10 (0.82 - 1.00) | **0.90 (0.82 - 1.00)*** |
| 30-34 | | | 1.04 (0.94 - 1.15) | 1.04 (0.94 - 1.15) |
| 35+ | | | 0.99 (0.84 - 1.16) | 0.98 (0.84 - 1.16) |
| Large Family (4+), Age 4 | | | **0.74 (0.95 - 0.84)***** | **0.74 (0.65 - 0.85)***** |
| Received Support or Protection Services | | | 0.92 (0.81 - 1.05) | 0.91 (0.79 - 1.04) |
| Child in Care | | | 1.05 (0.86 - 1.29) | 1.04 (0.85 - 1.28) |
| **BF/FF Variables** | | | | |
| Not Graduated at time of birth (vs. graduated) | | | | |
| Not Graduated | | | | 1.00 (0.87 - 1.15) |
| Missing | | | | 0.92 (0.78 - 1.10) |
| Smoking during pregnancy (vs. no smoking) | | | | |
| Yes | | | | 0.98 (0.88 - 1.10) |
| Missing | | | | 0.79 (0.58- 1.07) |
| Substance use during pregnancy (vs. no substance use) | | | | |
| Yes | | | | 1.00 (0.87 - 1.16) |
| Missing | | | | 1.14 (0.87 - 1.49) |
| Single (vs. not single) | | | | |
| Yes | | | | 1.12 (0.99 - 1.28) |
| Missing | | | | 0.89 (0.61 - 1.30) |
| | c=0.55 | c=0.60 | c=0.61 | c=0.61 |

*** p <.0001, ** p <.01, * p <.05

Table B4: Logistic Regression Models of Morbidity at age 7 with BF/FF Variables (n=22,471)

| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) | Model 4<br>OR (95% CI) |
|---|---|---|---|---|
| **Base Variables** | | | | |
| Late Preterm (vs. Term) | **1.19 (1.03 - 1.38)*** | 1.00 (0.85 - 1.17) | 1.00 (0.85 - 1.17) | 1.00 (0.85 - 1.17) |
| Male (vs. Female) | **1.12 (1.04 - 1.21)**** | 1.06 (0.98 - 1.14) | 1.05 (0.98 - 1.14) | 1.05 (0.97 - 1.14) |
| **Medical Variables** | | | | |
| Size for Gestational Age (vs. AGA) | | | | |
| SGA | | 0.99 (0.86 - 1.14) | 1.00 (0.87 - 1.15) | 1.00 (0.87 - 1.15) |
| LGA | | 0.89 (0.79 - 1.01) | 0.90 (0.55 - 1.01) | 0.90 (0.80 - 1.02) |
| Maternal Diabetes | | **1.26 (1.05 - 1.52)*** | **1.26 (1.04 - 1.52)*** | **1.26 (1.04 - 1.52)*** |
| Multiple Birth | | 0.81 (0.54 - 1.21) | 0.83 (0.55 - 1.24) | 0.83 (0.56 - 1.24) |
| ADG Sum | | **1.22 (1.20 - 1.24)***** | **1.23 (1.20 - 1.25)***** | **1.23 (1.20 - 1.25)***** |
| **Social Variables** | | | | |
| Income Quintile (vs. Quintile 5) | | | | |
| NF | | | 0.45 (0.19 - 1.08) | 0.45 (0.19 - 1.08) |
| Quintile 1 | | | **0.81 (0.70 - 0.93)**** | **0.80 (0.70 - 0.92)**** |
| Quintile 2 | | | 0.89 (0.79 - 1.01) | 0.89 (0.79 - 1.01) |
| Quntile 3 | | | 0.96 (0.85 - 1.08) | 0.96 (0.85 - 1.08) |
| Quintile 4 | | | 0.94 (0.83 - 1.05) | 0.93 (0.83 - 1.05) |
| Income Assistance, Age 4 | | | **1.18 (1.02 - 1.37)*** | **1.18 (1.02 - 1.38)*** |
| Mother's Age at First Birth (vs. 25-29) | | | | |
| <18 | | | 0.96 (0.80 - 1.15) | 0.95 (0.79 - 1.15) |
| 18-19 | | | **0.82 (0.70 - 0.96)*** | **0.81 (0.69 - 0.95)**** |
| 20-24 | | | **0.89 (0.80 - 0.99)*** | **0.89 (0.79 - 0.99)*** |
| 30-34 | | | 1.08 (0.97 - 1.21) | 1.08 (0.97 - 1.21) |
| 35+ | | | 1.07 (0.90 - 1.27) | 1.06 (0.89 - 1.27) |
| Large Family (4+), Age 4 | | | **0.75 (0.64 - 0.88)**** | **0.75 (0.64 - 0.88)**** |
| Received Support or Protection Services | | | 1.13 (0.99 - 1.30) | 1.13 (0.98 - 1.30) |
| Child in Care | | | 1.05 (0.85 - 1.31) | 1.05 (0.89 - 1.27) |
| **BF/FF Variables** | | | | |
| Not Graduated at time of birth (vs. graduated) | | | | |
| Not Graduated | | | | 1.01 (0.87 - 1.18) |
| Missing | | | | 0.88 (0.72 - 1.07) |
| Smoking during pregnancy (vs. no smoking) | | | | |
| Yes | | | | 1.07 (0.95 - 1.20) |
| Missing | | | | 0.86 (0.62 - 1.20) |
| Substance use during pregnancy (vs. no substance use) | | | | |
| Yes | | | | 1.02 (0.87 - 1.20) |
| Missing | | | | 1.15 (0.86 - 1.54) |
| Single (vs. not single) | | | | |
| Yes | | | | 0.95 (0.82 - 1.10) |
| Missing | | | | 1.23 (0.84 - 1.81) |
| | c=0.52 | c=0.62 | c=0.62 | c=0.63 |

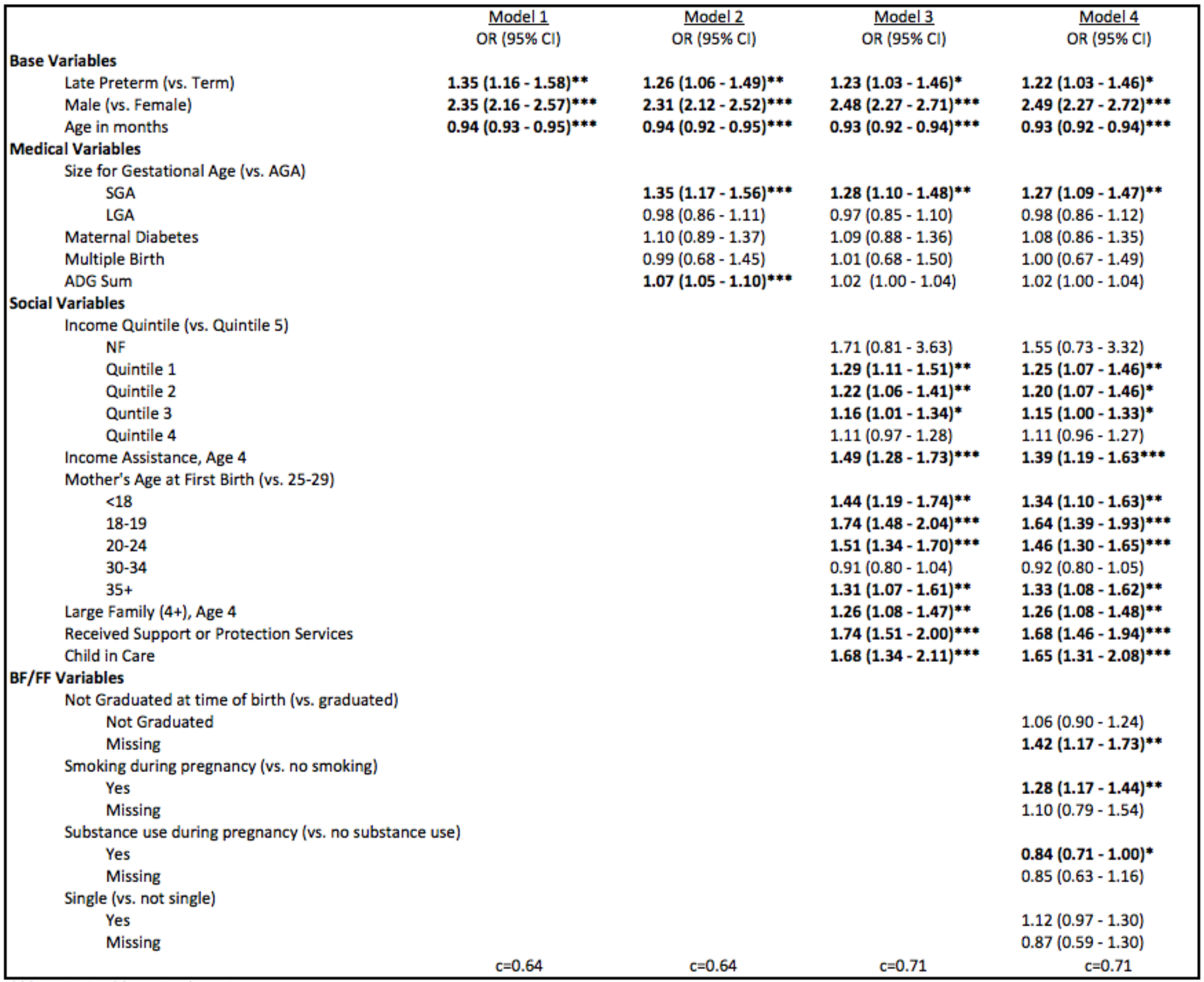
*** p <.0001, ** p <.01, * p <.05

Table B5: Logistic Regression Models of ADHD with BF/FF Variables (n=22,471)

| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) | Model 4<br>OR (95% CI) |
|---|---|---|---|---|
| **Base Variables** | | | | |
| Late Preterm (vs. Term) | **1.45 (1.19 - 1.77)**** | **1.25 (1.01 - 1.54)*** | 1.18 (0.95 - 1.47) | 1.19 (0.95 - 1.48) |
| Male (vs. Female) | **3.29 (2.87 - 3.76)***** | **3.15 (2.75 - 3.60)***** | **3.26 (2.85 - 3.74)***** | **3.27 (2.85 - 3.75)***** |
| **Medical Variables** | | | | |
| Size for Gestational Age (vs. AGA) | | | | |
| SGA | | 1.18 (0.97 - 1.43) | 1.11 (0.91 - 1.35) | 1.09 (0.89 - 1.33) |
| LGA | | **0.72 (0.59 - 0.87)**** | **0.73 (0.60 - 0.89)**** | **0.75 (0.61 - 0.91)**** |
| Maternal Diabetes | | **1.57 (1.21 - 2.02)**** | **1.59 (1.23 - 2.07)**** | **1.62 (1.25 - 2.11)**** |
| Multiple Birth | | 0.80 (0.46 - 1.40) | 0.82 (0.46 - 1.45) | 0.82 (0.47 - 1.46) |
| ADG Sum | | **1.16 (1.12 - 1.19)***** | **1.11 (1.07 - 1.14)***** | **1.10 (1.07 - 1.13)***** |
| **Social Variables** | | | | |
| Income Quintile (vs. Quintile 5) | | | | |
| NF | | | 1.23 (0.60 - 2.51) | 1.12 (0.55 - 2.31) |
| Quintile 1 | | | **1.12 (0.91 - 1.38)** | 1.07 (0.87 - 1.33) |
| Quintile 2 | | | 1.05 (0.86 - 1.28) | 1.03 (0.84 - 1.26) |
| Quntile 3 | | | 1.07 (0.87 - 1.30) | 1.05 (0.86 - 1.29) |
| Quintile 4 | | | 1.12 (0.92 - 1.37) | 1.11 (0.91 - 1.36) |
| Income Assistance, Age 4 | | | **1.44 (1.20 - 1.73)**** | **1.37 (1.13 - 1.65)**** |
| Mother's Age at First Birth (vs. 25-29) | | | | |
| <18 | | | 1.10 (0.86 - 1.40) | 1.01 (0.78 - 1.30) |
| 18-19 | | | **1.33 (1.08 - 1.64)**** | 1.23 (0.99 - 1.53) |
| 20-24 | | | 1.11 (0.94 - 1.32) | 1.07 (0.90 - 1.53) |
| 30-34 | | | 0.96 (0.79 - 1.16) | 0.96 (0.79 - 1.16) |
| 35+ | | | 1.11 (0.84 - 1.47) | 1.10 (0.83 - 1.47) |
| Large Family (4+), Age 4 | | | **0.67 (0.55 - 0.82)***** | **0.68 (0.56 - 0.83)**** |
| Received Support or Protection Services | | | **2.09 (1.75 - 2.50)***** | **1.97 (1.64 - 2.36)***** |
| Child in Care | | | **2.01 (1.61 - 2.51)***** | **1.89 (1.50 - 2.37)***** |
| **BF/FF Variables** | | | | |
| Not Graduated at time of birth (vs. graduated) | | | | |
| Not Graduated | | | | 1.05 (0.87 - 1.28) |
| Missing | | | | 1.00 (0.75 - 1.32) |
| Smoking during pregnancy (vs. no smoking) | | | | |
| Yes | | | | **1.25 (1.07 - 1.47)**** |
| Missing | | | | 1.00 (0.61 - 1.63) |
| Substance use during pregnancy (vs. no substance use) | | | | |
| Yes | | | | 1.22 (0.99 - 1.49) |
| Missing | | | | 0.91 (0.85 - 1.42) |
| Single (vs. not single) | | | | |
| Yes | | | | 1.10 (0.92 - 1.32) |
| Missing | | | | 0.74 (0.41 - 1.35) |
| | c=0.64 | c=0.69 | c=0.73 | c=0.73 |

*** p <.0001, ** p <.01, * p <.05

Table B6: Logistic Regression Models of ‘not ready’ in 1+ EDI domain with BF/FF variables (n=12,141)



| | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |
| **Base Variables** | | | | |
| Late Preterm (vs. Term) | 1.35 (1.16 - 1.58)** | 1.26 (1.06 - 1.49)** | 1.23 (1.03 - 1.46)* | 1.22 (1.03 - 1.46)* |
| Male (vs. Female) | 2.35 (2.16 - 2.57)*** | 2.31 (2.12 - 2.52)*** | 2.48 (2.27 - 2.71)*** | 2.49 (2.27 - 2.72)*** |
| Age in months | 0.94 (0.93 - 0.95)*** | 0.94 (0.92 - 0.95)*** | 0.93 (0.92 - 0.94)*** | 0.93 (0.92 - 0.94)*** |
| **Medical Variables** | | | | |
| Size for Gestational Age (vs. AGA) | | | | |
| SGA | | 1.35 (1.17 - 1.56)*** | 1.28 (1.10 - 1.48)** | 1.27 (1.09 - 1.47)** |
| LGA | | 0.98 (0.86 - 1.11) | 0.97 (0.85 - 1.10) | 0.98 (0.86 - 1.12) |
| Maternal Diabetes | | 1.10 (0.89 - 1.37) | 1.09 (0.88 - 1.36) | 1.08 (0.86 - 1.35) |
| Multiple Birth | | 0.99 (0.68 - 1.45) | 1.01 (0.68 - 1.50) | 1.00 (0.67 - 1.49) |
| ADG Sum | | 1.07 (1.05 - 1.10)*** | 1.02 (1.00 - 1.04) | 1.02 (1.00 - 1.04) |
| **Social Variables** | | | | |
| Income Quintile (vs. Quintile 5) | | | | |
| NF | | | 1.71 (0.81 - 3.63) | 1.55 (0.73 - 3.32) |
| Quintile 1 | | | 1.29 (1.11 - 1.51)** | 1.25 (1.07 - 1.46)** |
| Quintile 2 | | | 1.22 (1.06 - 1.41)** | 1.20 (1.07 - 1.46)* |
| Quntile 3 | | | 1.16 (1.01 - 1.34)* | 1.15 (1.00 - 1.33)* |
| Quintile 4 | | | 1.11 (0.97 - 1.28) | 1.11 (0.96 - 1.27) |
| Income Assistance, Age 4 | | | 1.49 (1.28 - 1.73)*** | 1.39 (1.19 - 1.63*** |
| Mother's Age at First Birth (vs. 25-29) | | | | |
| <18 | | | 1.44 (1.19 - 1.74)** | 1.34 (1.10 - 1.63)** |
| 18-19 | | | 1.74 (1.48 - 2.04)*** | 1.64 (1.39 - 1.93)*** |
| 20-24 | | | 1.51 (1.34 - 1.70)*** | 1.46 (1.30 - 1.65)*** |
| 30-34 | | | 0.91 (0.80 - 1.04) | 0.92 (0.80 - 1.05) |
| 35+ | | | 1.31 (1.07 - 1.61)** | 1.33 (1.08 - 1.62)** |
| Large Family (4+), Age 4 | | | 1.26 (1.08 - 1.47)** | 1.26 (1.08 - 1.48)** |
| Received Support or Protection Services | | | 1.74 (1.51 - 2.00)*** | 1.68 (1.46 - 1.94)*** |
| Child in Care | | | 1.68 (1.34 - 2.11)*** | 1.65 (1.31 - 2.08)*** |
| **BF/FF Variables** | | | | |
| Not Graduated at time of birth (vs. graduated) | | | | |
| Not Graduated | | | | 1.06 (0.90 - 1.24) |
| Missing | | | | 1.42 (1.17 - 1.73)** |
| Smoking during pregnancy (vs. no smoking) | | | | |
| Yes | | | | 1.28 (1.17 - 1.44)** |
| Missing | | | | 1.10 (0.79 - 1.54) |
| Substance use during pregnancy (vs. no substance use) | | | | |
| Yes | | | | 0.84 (0.71 - 1.00)* |
| Missing | | | | 0.85 (0.63 - 1.16) |
| Single (vs. not single) | | | | |
| Yes | | | | 1.12 (0.97 - 1.30) |
| Missing | | | | 0.87 (0.59 - 1.30) |
| | c=0.64 | c=0.64 | c=0.71 | c=0.71 |

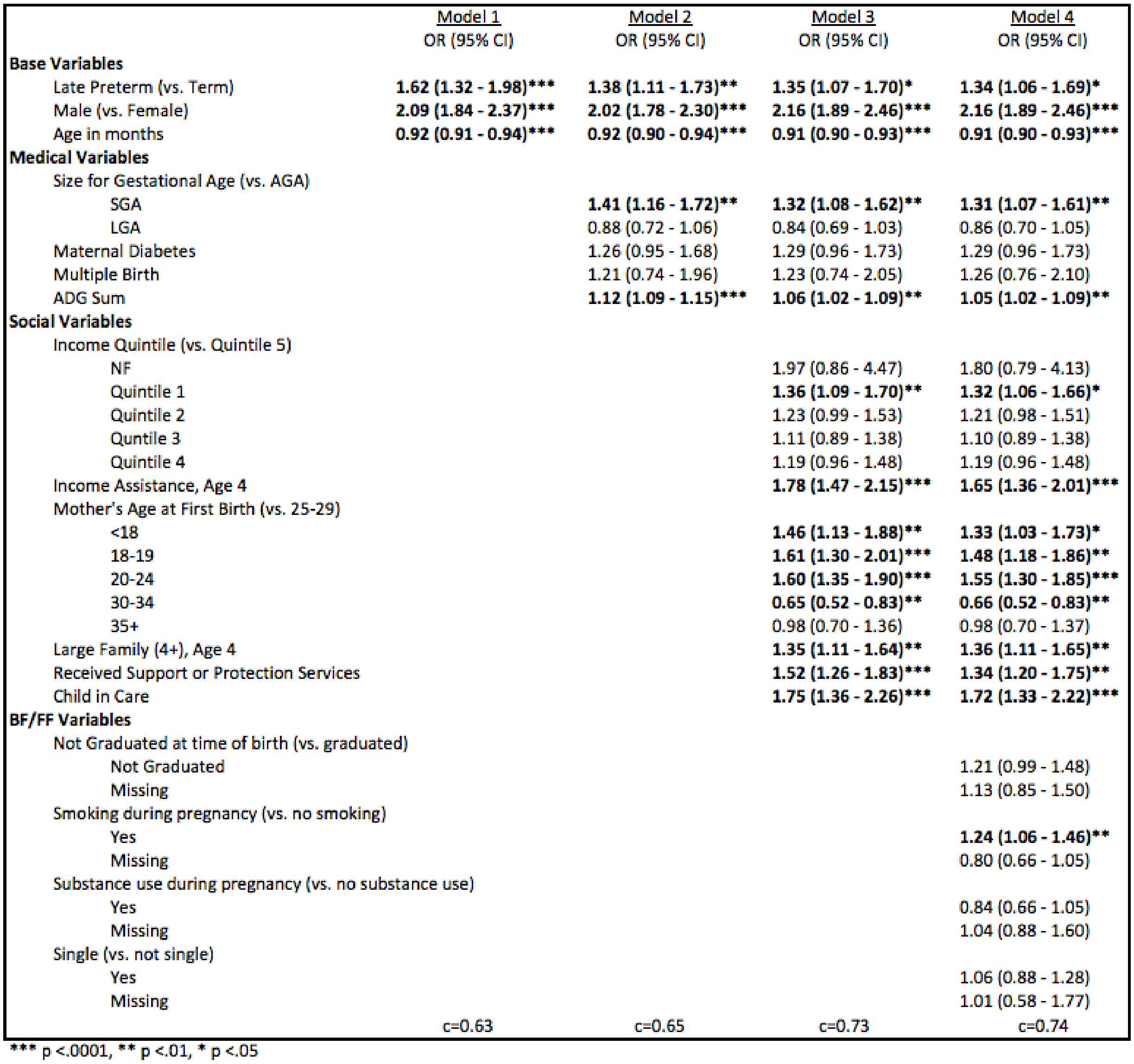
*** p <.0001, ** p <.01, * p <.05

Table B7: Logistic Regression Models of ‘not ready’ in 2+ EDI domain with BF/FF variables (n=12,141)

| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) | Model 4<br>OR (95% CI) |
|---|---|---|---|---|
| **Base Variables** | | | | |
| Late Preterm (vs. Term) | **1.40 (1.15 - 1.69)**** | 1.21 (0.98 - 1.49) | 1.17 (0.94 - 1.46) | 1.17 (0.94 - 1.45) |
| Male (vs. Female) | **2.67 (2.38 - 3.00)***** | **2.60 (2.32 - 2.92)***** | **2.79 (2.48 - 3.14)***** | **2.80 (2.48 - 3.15)***** |
| Age in months | **0.94 (0.93 - 0.95)***** | **0.94 (0.93 - 0.96)***** | **0.94 (0.92 - 0.95)***** | **0.94 (0.92 - 0.95)***** |
| **Medical Variables** | | | | |
| Size for Gestational Age (vs. AGA) | | | | |
| SGA | | **1.45 (1.21 - 1.72)***** | **1.37 (1.14 - 1.64)**** | **1.36 (1.13 - 1.62)**** |
| LGA | | 0.97 (0.82 - 1.15) | 0.95 (0.80 - 1.13) | 0.98 (0.82 - 1.16) |
| Maternal Diabetes | | 1.17 (0.90 - 1.52) | 1.17 (0.89 - 1.53) | 1.16 (0.88 - 1.53) |
| Multiple Birth | | 1.24 (0.79 - 1.95) | 1.26 (0.79 - 2.02) | 1.27 (0.79 - 2.04) |
| ADG Sum | | **1.11 (1.08 - 1.14)***** | **1.05 (1.03 - 1.08)**** | **1.05 (1.02 - 1.08)**** |
| **Social Variables** | | | | |
| Income Quintile (vs. Quintile 5) | | | | |
| NF | | | 1.26 (0.56 - 2.86) | 1.06 (0.46 - 2.43) |
| Quintile 1 | | | **1.27 (1.05 - 1.55)*** | 1.21 (0.99 - 1.48) |
| Quintile 2 | | | 1.20 (1.00 - 1.44) | 1.17 (0.97 - 1.40) |
| Quntile 3 | | | 1.05 (0.87 - 1.26) | 1.04 (0.86 - 1.25) |
| Quintile 4 | | | 1.08 (0.90 - 1.30) | 1.08 (0.89 - 1.30) |
| Income Assistance, Age 4 | | | **1.45 (1.22 - 1.73)**** | **1.30 (1.08 - 1.56)**** |
| Mother's Age at First Birth (vs. 25-29) | | | | |
| <18 | | | **1.44 (1.15 - 1.82)**** | **1.28 (1.01 - 1.62)*** |
| 18-19 | | | **1.62 (1.33 - 1.98)***** | **1.45 (1.18 - 1.78)**** |
| 20-24 | | | **1.58 (1.36 - 1.84)***** | **1.50 (1.28 - 1.75)***** |
| 30-34 | | | 0.98 (0.92 - 1.18) | 0.99 (0.82 - 1.19) |
| 35+ | | | 1.05 (0.79 - 1.39) | 1.06 (0.79 - 1.41) |
| Large Family (4+), Age 4 | | | **1.26 (1.05 - 1.50)*** | **1.27 (1.06 - 1.53)**** |
| Received Support or Protection Services | | | **1.79 (1.52 - 2.11)***** | **1.68 (1.42 - 1.99)***** |
| Child in Care | | | **1.69 (1.33 - 2.15)***** | **1.63 (1.28 - 2.08)***** |
| **BF/FF Variables** | | | | |
| Not Graduated at time of birth (vs. graduated) | | | | |
| Not Graduated | | | | 1.10 (0.92 - 1.33) |
| Missing | | | | **1.38 (1.08 - 1.76)**** |
| Smoking during pregnancy (vs. no smoking) | | | | |
| Yes | | | | **1.37 (1.18 - 1.59)***** |
| Missing | | | | 0.92 (0.59 - 1.43) |
| Substance use during pregnancy (vs. no substance use) | | | | |
| Yes | | | | 0.85 (0.69 - 1.05) |
| Missing | | | | 0.82 (0.55 - 1.22) |
| Single (vs. not single) | | | | |
| Yes | | | | **1.27 (1.07 - 1.51)**** |
| Missing | | | | 1.02 (0.63 - 1.66) |
| | c=0.65 | c=0.66 | c=0.72 | c=0.73 |

*** p <.0001, ** p <.01, * p <.05

Table B8: Logistic Regression Models of ‘not ready’ in language domain with BF/FF variables (n=12,075)



| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) | Model 4<br>OR (95% CI) |
|---|---|---|---|---|
| **Base Variables** | | | | |
| Late Preterm (vs. Term) | **1.62 (1.32 - 1.98)*** ** | **1.38 (1.11 - 1.73)** ** | **1.35 (1.07 - 1.70)* ** | **1.34 (1.06 - 1.69)* ** |
| Male (vs. Female) | **2.09 (1.84 - 2.37)*** ** | **2.02 (1.78 - 2.30)*** ** | **2.16 (1.89 - 2.46)*** ** | **2.16 (1.89 - 2.46)*** ** |
| Age in months | **0.92 (0.91 - 0.94)*** ** | **0.92 (0.90 - 0.94)*** ** | **0.91 (0.90 - 0.93)*** ** | **0.91 (0.90 - 0.93)*** ** |
| **Medical Variables** | | | | |
| Size for Gestational Age (vs. AGA) | | | | |
| SGA | | **1.41 (1.16 - 1.72)** ** | **1.32 (1.08 - 1.62)** ** | **1.31 (1.07 - 1.61)** ** |
| LGA | | 0.88 (0.72 - 1.06) | 0.84 (0.69 - 1.03) | 0.86 (0.70 - 1.05) |
| Maternal Diabetes | | 1.26 (0.95 - 1.68) | 1.29 (0.96 - 1.73) | 1.29 (0.96 - 1.73) |
| Multiple Birth | | 1.21 (0.74 - 1.96) | 1.23 (0.74 - 2.05) | 1.26 (0.76 - 2.10) |
| ADG Sum | | **1.12 (1.09 - 1.15)*** ** | **1.06 (1.02 - 1.09)** ** | **1.05 (1.02 - 1.09)** ** |
| **Social Variables** | | | | |
| Income Quintile (vs. Quintile 5) | | | | |
| NF | | | 1.97 (0.86 - 4.47) | 1.80 (0.79 - 4.13) |
| Quintile 1 | | | **1.36 (1.09 - 1.70)** ** | **1.32 (1.06 - 1.66)* ** |
| Quintile 2 | | | 1.23 (0.99 - 1.53) | 1.21 (0.98 - 1.51) |
| Quntile 3 | | | 1.11 (0.89 - 1.38) | 1.10 (0.89 - 1.38) |
| Quintile 4 | | | 1.19 (0.96 - 1.48) | 1.19 (0.96 - 1.48) |
| Income Assistance, Age 4 | | | **1.78 (1.47 - 2.15)*** ** | **1.65 (1.36 - 2.01)*** ** |
| Mother's Age at First Birth (vs. 25-29) | | | | |
| <18 | | | **1.46 (1.13 - 1.88)** ** | **1.33 (1.03 - 1.73)* ** |
| 18-19 | | | **1.61 (1.30 - 2.01)*** ** | **1.48 (1.18 - 1.86)** ** |
| 20-24 | | | **1.60 (1.35 - 1.90)*** ** | **1.55 (1.30 - 1.85)*** ** |
| 30-34 | | | **0.65 (0.52 - 0.83)** ** | **0.66 (0.52 - 0.83)** ** |
| 35+ | | | 0.98 (0.70 - 1.36) | 0.98 (0.70 - 1.37) |
| Large Family (4+), Age 4 | | | **1.35 (1.11 - 1.64)** ** | **1.36 (1.11 - 1.65)** ** |
| Received Support or Protection Services | | | **1.52 (1.26 - 1.83)*** ** | **1.34 (1.20 - 1.75)** ** |
| Child in Care | | | **1.75 (1.36 - 2.26)*** ** | **1.72 (1.33 - 2.22)*** ** |
| **BF/FF Variables** | | | | |
| Not Graduated at time of birth (vs. graduated) | | | | |
| Not Graduated | | | | 1.21 (0.99 - 1.48) |
| Missing | | | | 1.13 (0.85 - 1.50) |
| Smoking during pregnancy (vs. no smoking) | | | | |
| Yes | | | | **1.24 (1.06 - 1.46)** ** |
| Missing | | | | 0.80 (0.66 - 1.05) |
| Substance use during pregnancy (vs. no substance use) | | | | |
| Yes | | | | 0.84 (0.66 - 1.05) |
| Missing | | | | 1.04 (0.88 - 1.60) |
| Single (vs. not single) | | | | |
| Yes | | | | 1.06 (0.88 - 1.28) |
| Missing | | | | 1.01 (0.58 - 1.77) |
| | c=0.63 | c=0.65 | c=0.73 | c=0.74 |

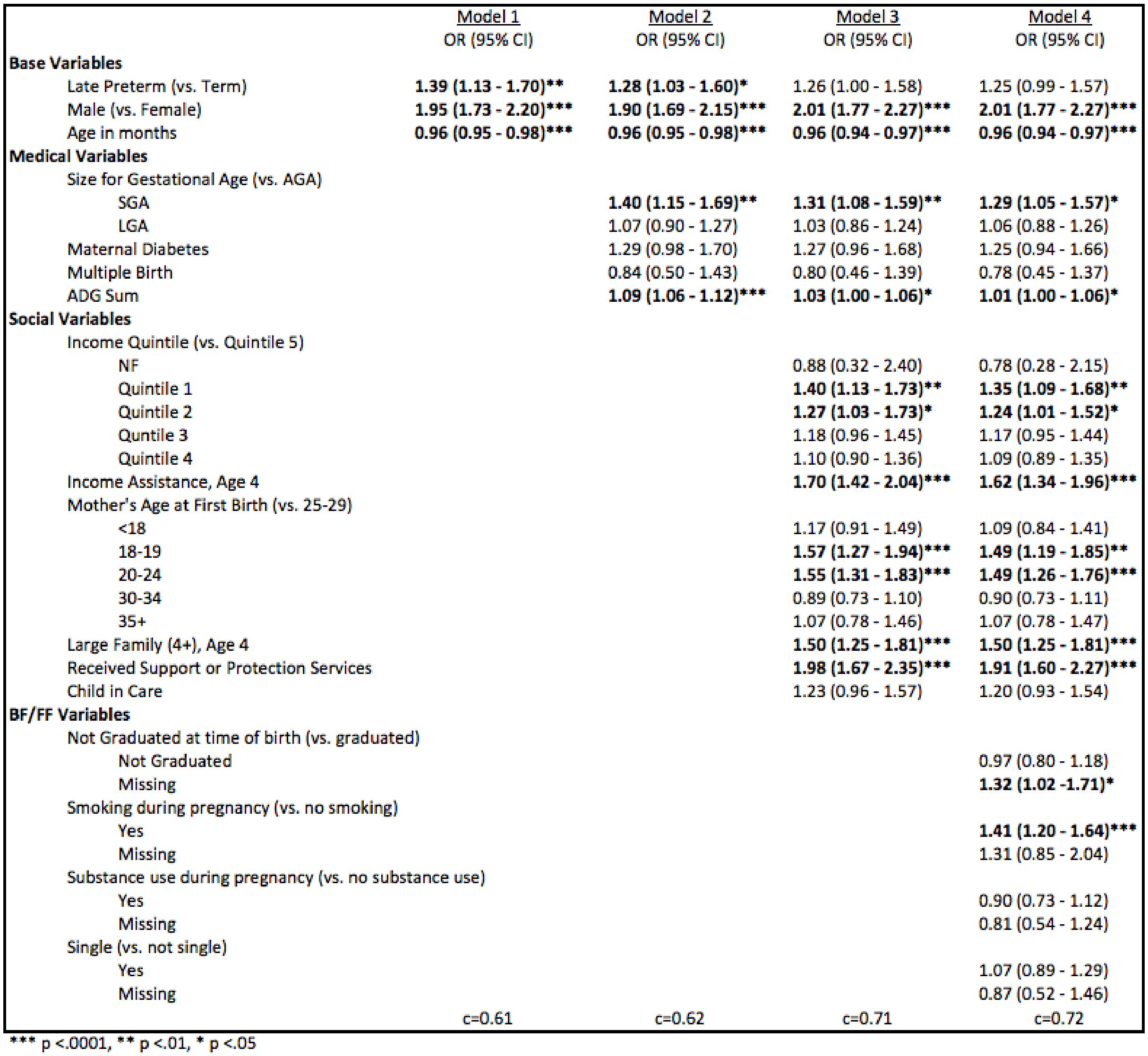
*** p <.0001, ** p <.01, * p <.05

Table B9: Logistic Regression Models of 'not ready' in communication domain with BF/FF variables (n=12,141)

| | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |
| **Base Variables** | | | | |
| Late Preterm (vs. Term) | **1.59 (1.28 - 1.97)*** ** | **1.37 (1.08 - 1.74)*** | **1.33 (1.04 - 1.70)*** | **1.33 (1.04 - 1.70)*** |
| Male (vs. Female) | **2.13 (1.86 - 2.44)*** ** | **2.07 (1.81 - 2.38)*** ** | **2.12 (1.85 - 2.44)*** ** | **2.13 (1.85 - 2.44)*** ** |
| Age in months | **0.94 (0.92 - 0.95)*** ** | **0.93 (0.92 - 0.95)*** ** | **0.93 (0.92 - 0.95)*** ** | **0.93 (0.92 - 2.05)*** ** |
| **Medical Variables** | | | | |
| Size for Gestational Age (vs. AGA) | | | | |
| SGA | | **1.75 (1.44 - 2.13)*** ** | **1.67 (1.37 - 2.04)*** ** | **1.68 (1.37 - 2.05)*** ** |
| LGA | | 1.07 (0.88 - 1.30) | 1.04 (0.85 - 1.26) | 1.05 (0.86 - 1.28) |
| Maternal Diabetes | | 1.24 (0.91 - 1.68) | 1.21 (0.89 - 1.65) | 1.19 (0.87 - 1.28) |
| Multiple Birth | | 1.35 (0.82 - 2.22) | 1.23 (0.74 - 2.04) | 1.23 (0.73 - 2.05) |
| ADG Sum | | **1.09 (1.06 - 1.12)*** ** | **1.05 (1.02 - 2.04)** ** | **1.05 (1.02 - 1.08)** ** |
| **Social Variables** | | | | |
| Income Quintile (vs. Quintile 5) | | | | |
| NF | | | 1.73 (0.66 - 4.50) | 1.53 (0.58 - 3.98) |
| Quintile 1 | | | **1.31 (1.03 - 1.65)*** | 1.26 (0.99 - 1.59) |
| Quintile 2 | | | **1.25 (1.00 - 1.56)*** | 1.23 (0.99 - 1.53) |
| Quntile 3 | | | 1.10 (0.89 - 1.38) | 1.10 (0.88 - 1.37) |
| Quintile 4 | | | 1.11 (0.89 - 1.38) | 1.12 (0.90 - 1.39) |
| Income Assistance, Age 4 | | | **1.34 (1.08 - 1.66)** ** | 1.20 (0.96 - 1.50) |
| Mother's Age at First Birth (vs. 25-29) | | | | |
| <18 | | | 1.07 (0.81 - 1.41) | 0.95 (0.71 - 1.26) |
| 18-19 | | | 1.13 (0.89 - 1.43) | 1.01 (0.79 - 1.30) |
| 20-24 | | | **1.39 (1.17 - 1.66)** ** | **1.34 (1.12 - 1.60)** ** |
| 30-34 | | | **0.72 (0.57 - 0.90)** ** | **0.72 (0.57 - 0.91)** ** |
| 35+ | | | 1.12 (0.81 - 1.53) | 1.14 (0.83 - 1.57) |
| Large Family (4+), Age 4 | | | **1.75 (1.44 - 2.14)*** ** | **1.75 (1.43 - 2.14)*** ** |
| Received Support or Protection Services | | | **1.40 (1.14 - 1.71)** ** | **1.33 (1.08 - 1.63)** ** |
| Child in Care | | | 1.22 (0.91 - 1.64) | 1.22 (0.90 - 1.64) |
| **BF/FF Variables** | | | | |
| Not Graduated at time of birth (vs. graduated) | | | | |
| Not Graduated | | | | **1.32 (1.06 - 1.64)*** |
| Missing | | | | **1.73 (1.33 - 2.26)*** ** |
| Smoking during pregnancy (vs. no smoking) | | | | |
| Yes | | | | **1.20 (1.01 - 1.44)*** |
| Missing | | | | 0.84 (0.48 - 1.45) |
| Substance use during pregnancy (vs. no substance use) | | | | |
| Yes | | | | **0.70 (0.54 - 0.91)** ** |
| Missing | | | | **0.59 (0.36 - 0.98)*** |
| Single (vs. not single) | | | | |
| Yes | | | | 1.19 (0.97 - 1.46) |
| Missing | | | | 0.82 (0.46 - 1.49) |
| | c=0.63 | c=0.65 | c=0.69 | c=0.70 |

*** p <.0001, ** p <.01, * p <.05

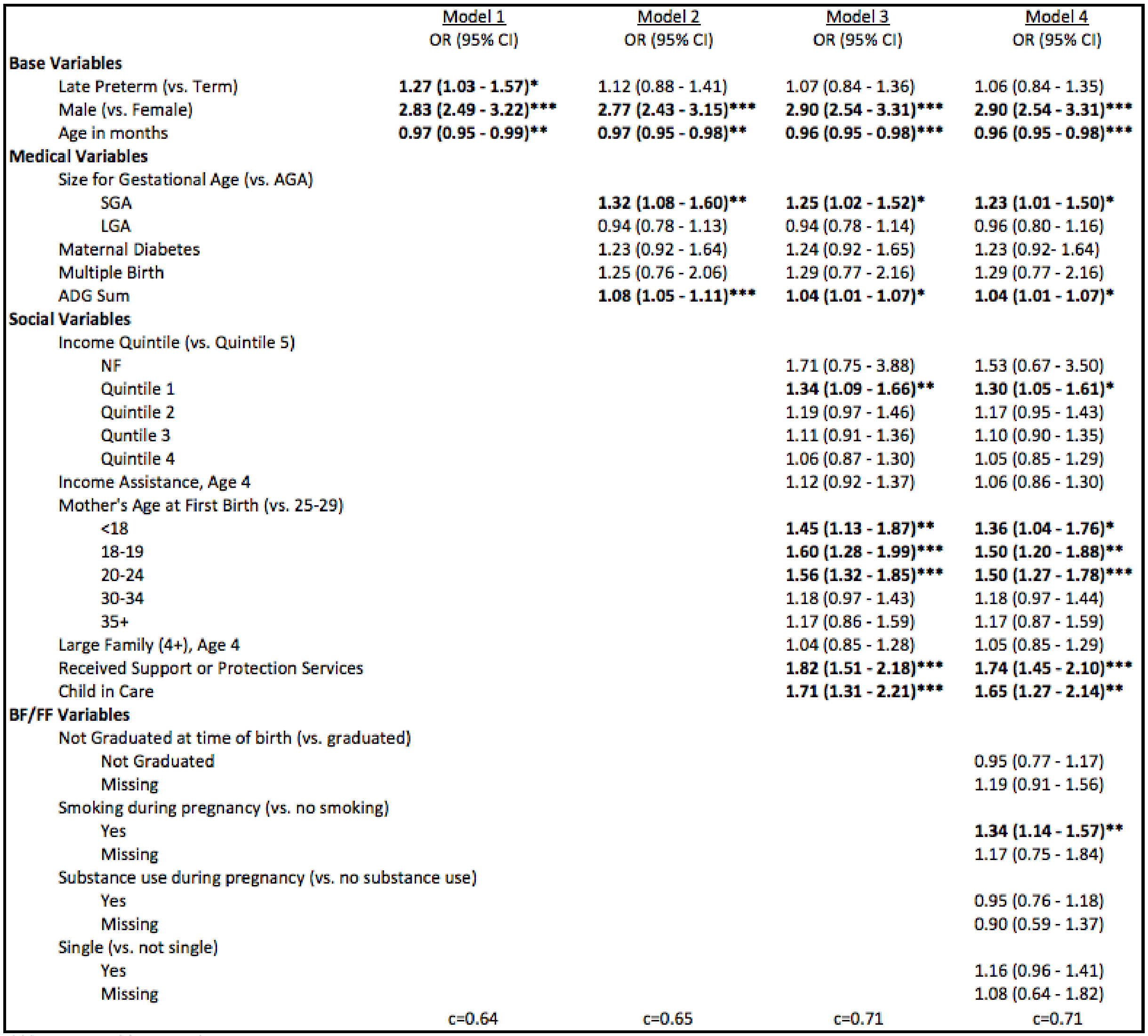
Table B10: Logistic Regression Models of ‘not ready’ in physical domain with BF/FF variables (n=12,117)



| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) | Model 4<br>OR (95% CI) |
|---|---|---|---|---|
| **Base Variables** | | | | |
| Late Preterm (vs. Term) | **1.39 (1.13 - 1.70)**** | **1.28 (1.03 - 1.60)*** | 1.26 (1.00 - 1.58) | 1.25 (0.99 - 1.57) |
| Male (vs. Female) | **1.95 (1.73 - 2.20)***** | **1.90 (1.69 - 2.15)***** | **2.01 (1.77 - 2.27)***** | **2.01 (1.77 - 2.27)***** |
| Age in months | **0.96 (0.95 - 0.98)***** | **0.96 (0.95 - 0.98)***** | **0.96 (0.94 - 0.97)***** | **0.96 (0.94 - 0.97)***** |
| **Medical Variables** | | | | |
| Size for Gestational Age (vs. AGA) | | | | |
| SGA | | **1.40 (1.15 - 1.69)**** | **1.31 (1.08 - 1.59)**** | **1.29 (1.05 - 1.57)*** |
| LGA | | 1.07 (0.90 - 1.27) | 1.03 (0.86 - 1.24) | 1.06 (0.88 - 1.26) |
| Maternal Diabetes | | 1.29 (0.98 - 1.70) | 1.27 (0.96 - 1.68) | 1.25 (0.94 - 1.66) |
| Multiple Birth | | 0.84 (0.50 - 1.43) | 0.80 (0.46 - 1.39) | 0.78 (0.45 - 1.37) |
| ADG Sum | | **1.09 (1.06 - 1.12)***** | **1.03 (1.00 - 1.06)*** | **1.01 (1.00 - 1.06)*** |
| **Social Variables** | | | | |
| Income Quintile (vs. Quintile 5) | | | | |
| NF | | | 0.88 (0.32 - 2.40) | 0.78 (0.28 - 2.15) |
| Quintile 1 | | | **1.40 (1.13 - 1.73)**** | **1.35 (1.09 - 1.68)**** |
| Quintile 2 | | | **1.27 (1.03 - 1.73)*** | **1.24 (1.01 - 1.52)*** |
| Quntile 3 | | | 1.18 (0.96 - 1.45) | 1.17 (0.95 - 1.44) |
| Quintile 4 | | | 1.10 (0.90 - 1.36) | 1.09 (0.89 - 1.35) |
| Income Assistance, Age 4 | | | **1.70 (1.42 - 2.04)***** | **1.62 (1.34 - 1.96)***** |
| Mother's Age at First Birth (vs. 25-29) | | | | |
| <18 | | | 1.17 (0.91 - 1.49) | 1.09 (0.84 - 1.41) |
| 18-19 | | | **1.57 (1.27 - 1.94)***** | **1.49 (1.19 - 1.85)**** |
| 20-24 | | | **1.55 (1.31 - 1.83)***** | **1.49 (1.26 - 1.76)***** |
| 30-34 | | | 0.89 (0.73 - 1.10) | 0.90 (0.73 - 1.11) |
| 35+ | | | 1.07 (0.78 - 1.46) | 1.07 (0.78 - 1.47) |
| Large Family (4+), Age 4 | | | **1.50 (1.25 - 1.81)***** | **1.50 (1.25 - 1.81)***** |
| Received Support or Protection Services | | | **1.98 (1.67 - 2.35)***** | **1.91 (1.60 - 2.27)***** |
| Child in Care | | | 1.23 (0.96 - 1.57) | 1.20 (0.93 - 1.54) |
| **BF/FF Variables** | | | | |
| Not Graduated at time of birth (vs. graduated) | | | | |
| Not Graduated | | | | 0.97 (0.80 - 1.18) |
| Missing | | | | **1.32 (1.02 -1.71)*** |
| Smoking during pregnancy (vs. no smoking) | | | | |
| Yes | | | | **1.41 (1.20 - 1.64)***** |
| Missing | | | | 1.31 (0.85 - 2.04) |
| Substance use during pregnancy (vs. no substance use) | | | | |
| Yes | | | | 0.90 (0.73 - 1.12) |
| Missing | | | | 0.81 (0.54 - 1.24) |
| Single (vs. not single) | | | | |
| Yes | | | | 1.07 (0.89 - 1.29) |
| Missing | | | | 0.87 (0.52 - 1.46) |
| | c=0.61 | c=0.62 | c=0.71 | c=0.72 |

*** p <.0001, ** p <.01, * p <.05

Table B11: Logistic Regression Models of 'not ready' in social domain with BF/FF variables (n=12,137)



| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) | Model 4<br>OR (95% CI) |
|---|---|---|---|---|
| **Base Variables** | | | | |
| Late Preterm (vs. Term) | **1.27 (1.03 - 1.57)*** | 1.12 (0.88 - 1.41) | 1.07 (0.84 - 1.36) | 1.06 (0.84 - 1.35) |
| Male (vs. Female) | **2.83 (2.49 - 3.22)***** | **2.77 (2.43 - 3.15)***** | **2.90 (2.54 - 3.31)***** | **2.90 (2.54 - 3.31)***** |
| Age in months | **0.97 (0.95 - 0.99)**** | **0.97 (0.95 - 0.98)**** | **0.96 (0.95 - 0.98)***** | **0.96 (0.95 - 0.98)***** |
| **Medical Variables** | | | | |
| Size for Gestational Age (vs. AGA) | | | | |
| SGA | | **1.32 (1.08 - 1.60)**** | **1.25 (1.02 - 1.52)*** | **1.23 (1.01 - 1.50)*** |
| LGA | | 0.94 (0.78 - 1.13) | 0.94 (0.78 - 1.14) | 0.96 (0.80 - 1.16) |
| Maternal Diabetes | | 1.23 (0.92 - 1.64) | 1.24 (0.92 - 1.65) | 1.23 (0.92- 1.64) |
| Multiple Birth | | 1.25 (0.76 - 2.06) | 1.29 (0.77 - 2.16) | 1.29 (0.77 - 2.16) |
| ADG Sum | | **1.08 (1.05 - 1.11)***** | **1.04 (1.01 - 1.07)*** | **1.04 (1.01 - 1.07)*** |
| **Social Variables** | | | | |
| Income Quintile (vs. Quintile 5) | | | | |
| NF | | | 1.71 (0.75 - 3.88) | 1.53 (0.67 - 3.50) |
| Quintile 1 | | | **1.34 (1.09 - 1.66)**** | **1.30 (1.05 - 1.61)*** |
| Quintile 2 | | | 1.19 (0.97 - 1.46) | 1.17 (0.95 - 1.43) |
| Quntile 3 | | | 1.11 (0.91 - 1.36) | 1.10 (0.90 - 1.35) |
| Quintile 4 | | | 1.06 (0.87 - 1.30) | 1.05 (0.85 - 1.29) |
| Income Assistance, Age 4 | | | 1.12 (0.92 - 1.37) | 1.06 (0.86 - 1.30) |
| Mother's Age at First Birth (vs. 25-29) | | | | |
| <18 | | | **1.45 (1.13 - 1.87)**** | **1.36 (1.04 - 1.76)*** |
| 18-19 | | | **1.60 (1.28 - 1.99)***** | **1.50 (1.20 - 1.88)**** |
| 20-24 | | | **1.56 (1.32 - 1.85)***** | **1.50 (1.27 - 1.78)***** |
| 30-34 | | | 1.18 (0.97 - 1.43) | 1.18 (0.97 - 1.44) |
| 35+ | | | 1.17 (0.86 - 1.59) | 1.17 (0.87 - 1.59) |
| Large Family (4+), Age 4 | | | 1.04 (0.85 - 1.28) | 1.05 (0.85 - 1.29) |
| Received Support or Protection Services | | | **1.82 (1.51 - 2.18)***** | **1.74 (1.45 - 2.10)***** |
| Child in Care | | | **1.71 (1.31 - 2.21)***** | **1.65 (1.27 - 2.14)**** |
| **BF/FF Variables** | | | | |
| Not Graduated at time of birth (vs. graduated) | | | | |
| Not Graduated | | | | 0.95 (0.77 - 1.17) |
| Missing | | | | 1.19 (0.91 - 1.56) |
| Smoking during pregnancy (vs. no smoking) | | | | |
| Yes | | | | **1.34 (1.14 - 1.57)**** |
| Missing | | | | 1.17 (0.75 - 1.84) |
| Substance use during pregnancy (vs. no substance use) | | | | |
| Yes | | | | 0.95 (0.76 - 1.18) |
| Missing | | | | 0.90 (0.59 - 1.37) |
| Single (vs. not single) | | | | |
| Yes | | | | 1.16 (0.96 - 1.41) |
| Missing | | | | 1.08 (0.64 - 1.82) |
| | c=0.64 | c=0.65 | c=0.71 | c=0.71 |

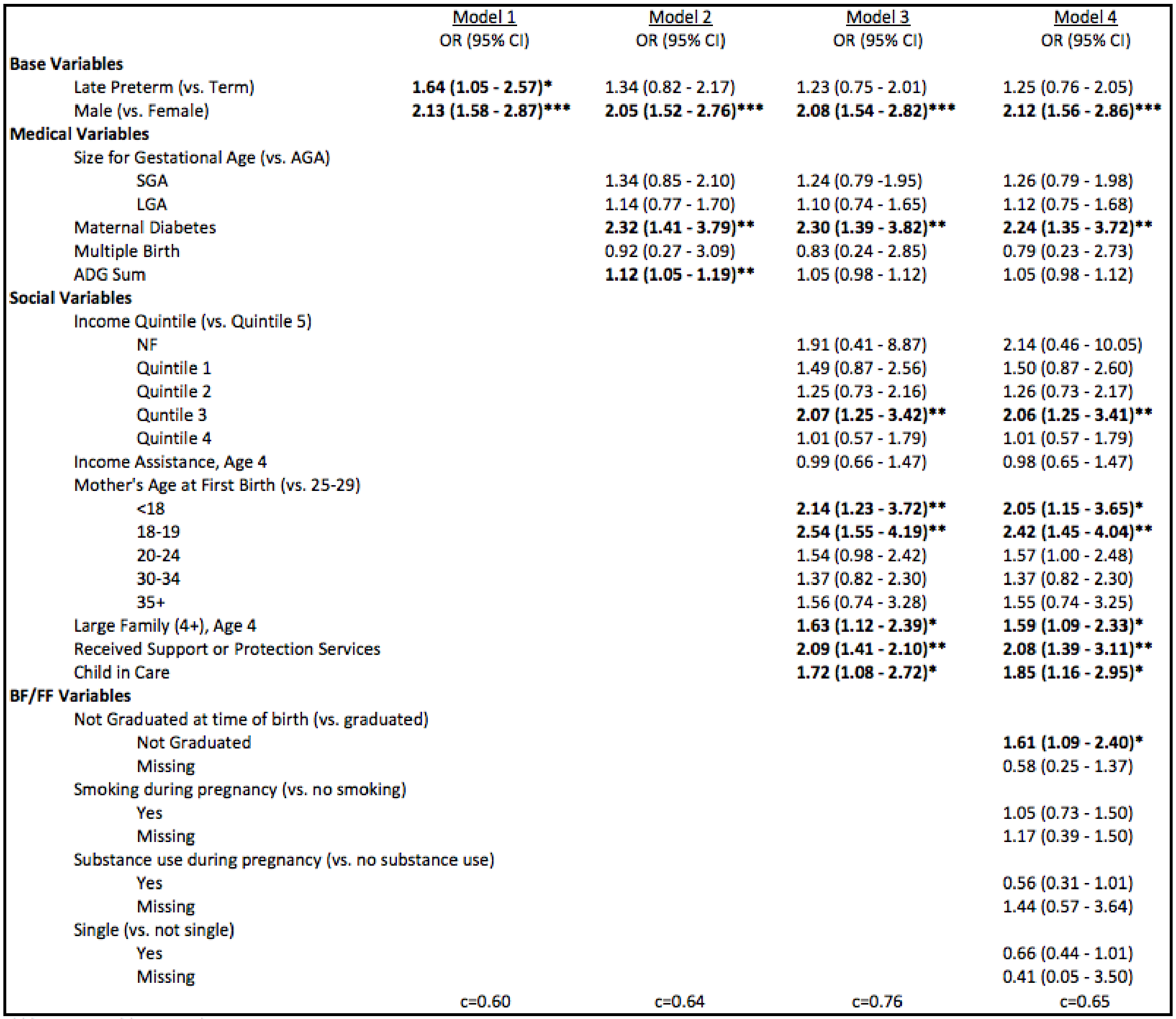
*** p <.0001, ** p <.01, * p <.05

Table B12: Logistic Regression Models of ‘not ready’ in emotional domain with BF/FF variables (n=12,060)

| | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |
| **Base Variables** | | | | |
| Late Preterm (vs. Term) | **1.27 (1.03 - 1.57)*** | 1.24 (0.99 - 1.55) | 1.18 (0.94 - 1.49) | 1.18 (0.93 - 1.48) |
| Male (vs. Female) | **3.57 (3.13 - 4.08)***** | **3.51 (3.07 - 4.01)***** | **3.62 (3.16 - 4.14)***** | **3.63 (3.17 - 4.15)***** |
| Age in months | **0.96 (0.95 - 0.98)***** | **0.96 (0.95 - 0.98)***** | **0.96 (0.94 - 0.98)***** | **0.96 (0.94 - 0.98)***** |
| **Medical Variables** | | | | |
| Size for Gestational Age (vs. AGA) | | | | |
| SGA | | **1.29 (1.06 - 1.57)*** | **1.24 (1.02 - 1.51)*** | **1.23 (1.01 - 1.50)*** |
| LGA | | 1.04 (0.87 - 1.23) | 1.05 (0.88 - 1.26) | 1.07 (0.89 - 1.28) |
| Maternal Diabetes | | 1.09 (0.82 - 1.47) | 1.09 (0.81 - 1.47) | 1.09 (0.81 - 1.46) |
| Multiple Birth | | 0.76 (0.44 - 1.34) | 0.75 (0.42 - 1.34) | 0.76 (0.43 - 1.35) |
| ADG Sum | | **1.06 (1.03 - 1.09)***** | **1.03 (1.00 - 1.06)*** | **1.03 (1.00 - 1.06)*** |
| **Social Variables** | | | | |
| Income Quintile (vs. Quintile 5) | | | | |
| NF | | | 1.11 (0.46 - 2.67) | 1.01 (0.41 - 2.44) |
| Quintile 1 | | | 1.18 (0.95 - 1.45) | 1.14 (0.92 - 1.42) |
| Quintile 2 | | | 1.19 (0.98 - 1.44) | 1.17 (0.96 - 1.42) |
| Quntile 3 | | | 1.11 (0.91 - 1.34) | 1.10 (0.91 - 1.34) |
| Quintile 4 | | | 1.16 (0.96 - 1.40) | 1.15 (0.95 - 1.40) |
| Income Assistance, Age 4 | | | 0.90 (0.73 - 1.10) | 0.84 (0.68 - 1.04) |
| Mother's Age at First Birth (vs. 25-29) | | | | |
| <18 | | | 1.27 (0.98 - 1.64) | 1.19 (0.91 - 1.55) |
| 18-19 | | | **1.49 (1.20 - 1.85)**** | **1.40 (1.12 - 1.75)**** |
| 20-24 | | | **1.39 (1.18 - 1.64)**** | **1.35 (1.14 - 1.59)**** |
| 30-34 | | | 1.17 (0.97 - 1.40) | 1.17 (0.97 - 1.41) |
| 35+ | | | **1.48 (1.14 - 1.94)**** | **1.48 (1.13 - 1.94)**** |
| Large Family (4+), Age 4 | | | 0.97 (0.79 - 1.20) | 0.98 (0.79 - 1.21) |
| Received Support or Protection Services | | | **1.94 (1.61 - 2.33)***** | **1.87 (1.26 - 2.16)***** |
| Child in Care | | | **1.70 (1.30 - 2.22)***** | **1.65 (1.26 - 2.16)**** |
| **BF/FF Variables** | | | | |
| Not Graduated at time of birth (vs. graduated) | | | | |
| Not Graduated | | | | 1.03 (0.83 - 1.27) |
| Missing | | | | 1.13 (0.86 - 1.48) |
| Smoking during pregnancy (vs. no smoking) | | | | |
| Yes | | | | **1.20 (1.02 - 1.42)*** |
| Missing | | | | 0.92 (0.57 - 1.46) |
| Substance use during pregnancy (vs. no substance use) | | | | |
| Yes | | | | 0.93 (0.74 - 1.16) |
| Missing | | | | 1.17 (0.79 - 1.74) |
| Single (vs. not single) | | | | |
| Yes | | | | 1.18 (0.97 - 1.44) |
| Missing | | | | 1.02 (0.60 - 1.75) |
| | c=0.67 | c=0.67 | c=0.71 | c=0.71 |

*** p <.0001, ** p <.01, * p <.05

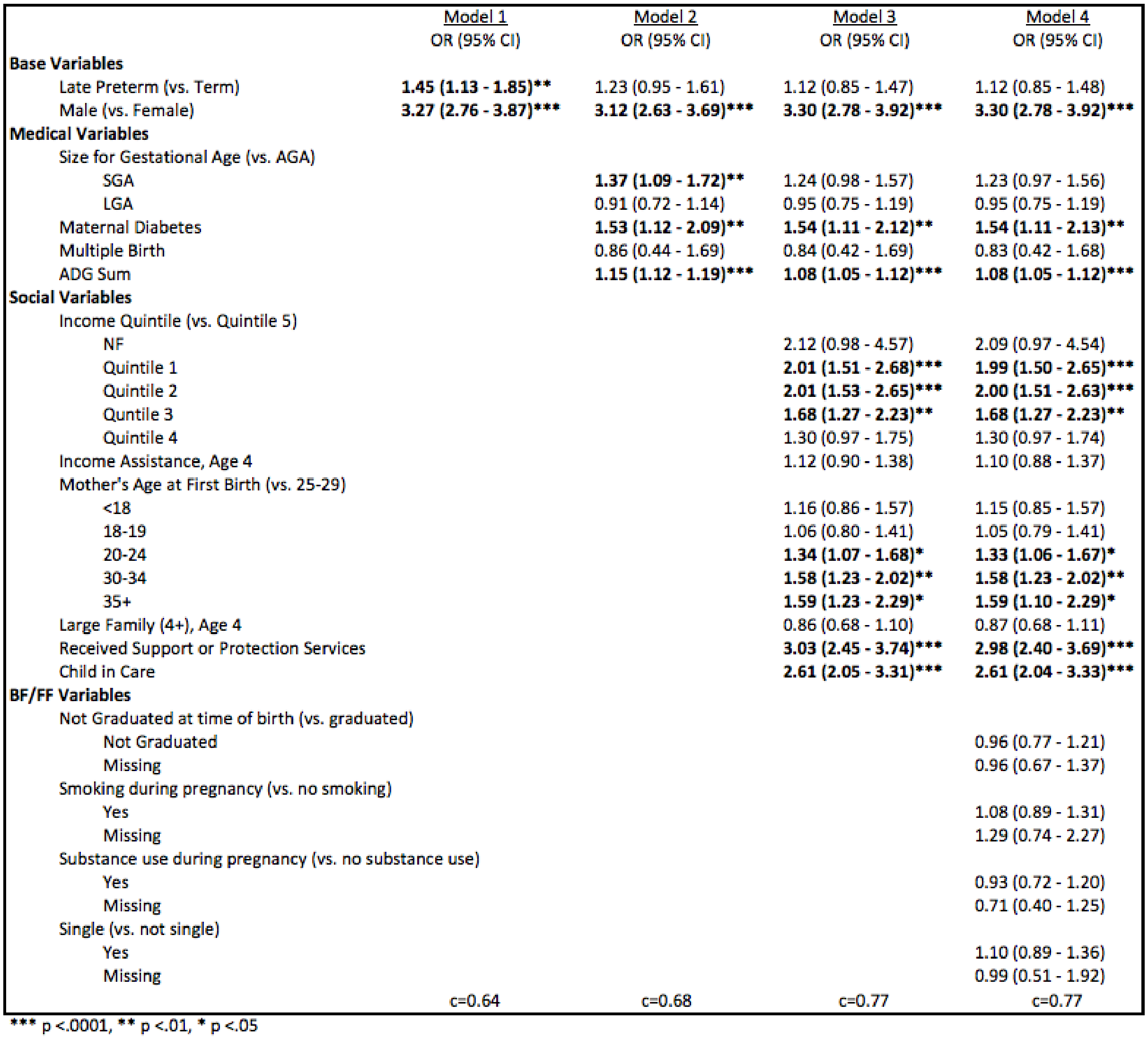
Table B13: Logistic Regression Models of Grade Repetition with BF/FF Variables (n=21,651)



| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) | Model 4<br>OR (95% CI) |
|---|---|---|---|---|
| **Base Variables** | | | | |
| Late Preterm (vs. Term) | **1.64 (1.05 - 2.57)*** | 1.34 (0.82 - 2.17) | 1.23 (0.75 - 2.01) | 1.25 (0.76 - 2.05) |
| Male (vs. Female) | **2.13 (1.58 - 2.87)***** | **2.05 (1.52 - 2.76)***** | **2.08 (1.54 - 2.82)***** | **2.12 (1.56 - 2.86)***** |
| **Medical Variables** | | | | |
| Size for Gestational Age (vs. AGA) | | | | |
| SGA | | 1.34 (0.85 - 2.10) | 1.24 (0.79 -1.95) | 1.26 (0.79 - 1.98) |
| LGA | | 1.14 (0.77 - 1.70) | 1.10 (0.74 - 1.65) | 1.12 (0.75 - 1.68) |
| Maternal Diabetes | | **2.32 (1.41 - 3.79)**** | **2.30 (1.39 - 3.82)**** | **2.24 (1.35 - 3.72)**** |
| Multiple Birth | | 0.92 (0.27 - 3.09) | 0.83 (0.24 - 2.85) | 0.79 (0.23 - 2.73) |
| ADG Sum | | **1.12 (1.05 - 1.19)**** | 1.05 (0.98 - 1.12) | 1.05 (0.98 - 1.12) |
| **Social Variables** | | | | |
| Income Quintile (vs. Quintile 5) | | | | |
| NF | | | 1.91 (0.41 - 8.87) | 2.14 (0.46 - 10.05) |
| Quintile 1 | | | 1.49 (0.87 - 2.56) | 1.50 (0.87 - 2.60) |
| Quintile 2 | | | 1.25 (0.73 - 2.16) | 1.26 (0.73 - 2.17) |
| Quntile 3 | | | **2.07 (1.25 - 3.42)**** | **2.06 (1.25 - 3.41)**** |
| Quintile 4 | | | 1.01 (0.57 - 1.79) | 1.01 (0.57 - 1.79) |
| Income Assistance, Age 4 | | | 0.99 (0.66 - 1.47) | 0.98 (0.65 - 1.47) |
| Mother's Age at First Birth (vs. 25-29) | | | | |
| <18 | | | **2.14 (1.23 - 3.72)**** | **2.05 (1.15 - 3.65)*** |
| 18-19 | | | **2.54 (1.55 - 4.19)**** | **2.42 (1.45 - 4.04)**** |
| 20-24 | | | 1.54 (0.98 - 2.42) | 1.57 (1.00 - 2.48) |
| 30-34 | | | 1.37 (0.82 - 2.30) | 1.37 (0.82 - 2.30) |
| 35+ | | | 1.56 (0.74 - 3.28) | 1.55 (0.74 - 3.25) |
| Large Family (4+), Age 4 | | | **1.63 (1.12 - 2.39)*** | **1.59 (1.09 - 2.33)*** |
| Received Support or Protection Services | | | **2.09 (1.41 - 2.10)**** | **2.08 (1.39 - 3.11)**** |
| Child in Care | | | **1.72 (1.08 - 2.72)*** | **1.85 (1.16 - 2.95)*** |
| **BF/FF Variables** | | | | |
| Not Graduated at time of birth (vs. graduated) | | | | |
| Not Graduated | | | | **1.61 (1.09 - 2.40)*** |
| Missing | | | | 0.58 (0.25 - 1.37) |
| Smoking during pregnancy (vs. no smoking) | | | | |
| Yes | | | | 1.05 (0.73 - 1.50) |
| Missing | | | | 1.17 (0.39 - 1.50) |
| Substance use during pregnancy (vs. no substance use) | | | | |
| Yes | | | | 0.56 (0.31 - 1.01) |
| Missing | | | | 1.44 (0.57 - 3.64) |
| Single (vs. not single) | | | | |
| Yes | | | | 0.66 (0.44 - 1.01) |
| Missing | | | | 0.41 (0.05 - 3.50) |
| | c=0.60 | c=0.64 | c=0.76 | c=0.65 |

*** p <.0001, ** p <.01, * p <.05

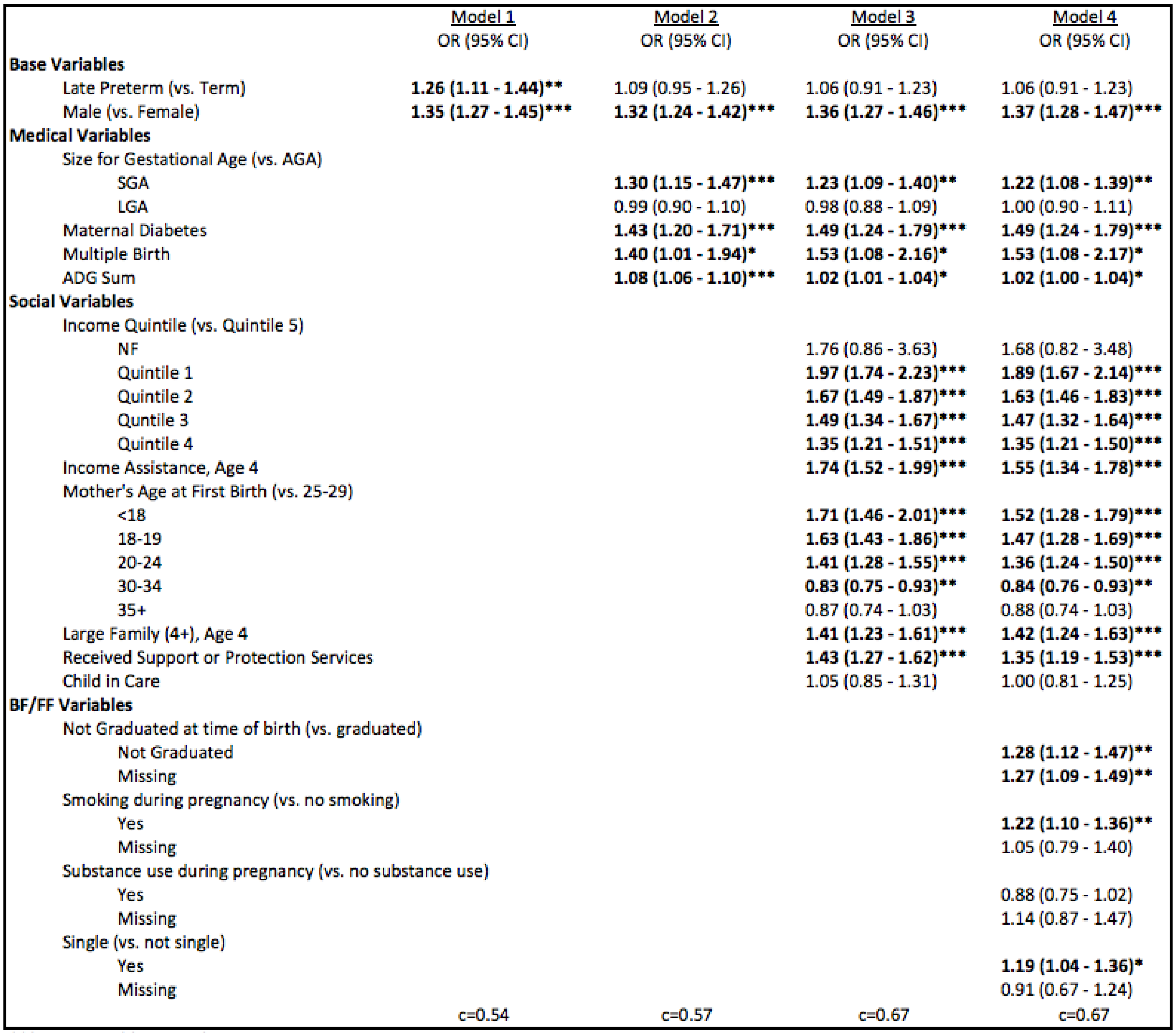
Table B14: Logistic Regression Models of Receipt of Special Education Funding with BF/FF Variables (n=22,471)



| | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |
| **Base Variables** | | | | |
| Late Preterm (vs. Term) | 1.45 (1.13 - 1.85)** | 1.23 (0.95 - 1.61) | 1.12 (0.85 - 1.47) | 1.12 (0.85 - 1.48) |
| Male (vs. Female) | 3.27 (2.76 - 3.87)*** | 3.12 (2.63 - 3.69)*** | 3.30 (2.78 - 3.92)*** | 3.30 (2.78 - 3.92)*** |
| **Medical Variables** | | | | |
| Size for Gestational Age (vs. AGA) | | | | |
| SGA | | 1.37 (1.09 - 1.72)** | 1.24 (0.98 - 1.57) | 1.23 (0.97 - 1.56) |
| LGA | | 0.91 (0.72 - 1.14) | 0.95 (0.75 - 1.19) | 0.95 (0.75 - 1.19) |
| Maternal Diabetes | | 1.53 (1.12 - 2.09)** | 1.54 (1.11 - 2.12)** | 1.54 (1.11 - 2.13)** |
| Multiple Birth | | 0.86 (0.44 - 1.69) | 0.84 (0.42 - 1.69) | 0.83 (0.42 - 1.68) |
| ADG Sum | | 1.15 (1.12 - 1.19)*** | 1.08 (1.05 - 1.12)*** | 1.08 (1.05 - 1.12)*** |
| **Social Variables** | | | | |
| Income Quintile (vs. Quintile 5) | | | | |
| NF | | | 2.12 (0.98 - 4.57) | 2.09 (0.97 - 4.54) |
| Quintile 1 | | | 2.01 (1.51 - 2.68)*** | 1.99 (1.50 - 2.65)*** |
| Quintile 2 | | | 2.01 (1.53 - 2.65)*** | 2.00 (1.51 - 2.63)*** |
| Quntile 3 | | | 1.68 (1.27 - 2.23)** | 1.68 (1.27 - 2.23)** |
| Quintile 4 | | | 1.30 (0.97 - 1.75) | 1.30 (0.97 - 1.74) |
| Income Assistance, Age 4 | | | 1.12 (0.90 - 1.38) | 1.10 (0.88 - 1.37) |
| Mother's Age at First Birth (vs. 25-29) | | | | |
| <18 | | | 1.16 (0.86 - 1.57) | 1.15 (0.85 - 1.57) |
| 18-19 | | | 1.06 (0.80 - 1.41) | 1.05 (0.79 - 1.41) |
| 20-24 | | | 1.34 (1.07 - 1.68)* | 1.33 (1.06 - 1.67)* |
| 30-34 | | | 1.58 (1.23 - 2.02)** | 1.58 (1.23 - 2.02)** |
| 35+ | | | 1.59 (1.23 - 2.29)* | 1.59 (1.10 - 2.29)* |
| Large Family (4+), Age 4 | | | 0.86 (0.68 - 1.10) | 0.87 (0.68 - 1.11) |
| Received Support or Protection Services | | | 3.03 (2.45 - 3.74)*** | 2.98 (2.40 - 3.69)*** |
| Child in Care | | | 2.61 (2.05 - 3.31)*** | 2.61 (2.04 - 3.33)*** |
| **BF/FF Variables** | | | | |
| Not Graduated at time of birth (vs. graduated) | | | | |
| Not Graduated | | | | 0.96 (0.77 - 1.21) |
| Missing | | | | 0.96 (0.67 - 1.37) |
| Smoking during pregnancy (vs. no smoking) | | | | |
| Yes | | | | 1.08 (0.89 - 1.31) |
| Missing | | | | 1.29 (0.74 - 2.27) |
| Substance use during pregnancy (vs. no substance use) | | | | |
| Yes | | | | 0.93 (0.72 - 1.20) |
| Missing | | | | 0.71 (0.40 - 1.25) |
| Single (vs. not single) | | | | |
| Yes | | | | 1.10 (0.89 - 1.36) |
| Missing | | | | 0.99 (0.51 - 1.92) |
| | c=0.64 | c=0.68 | c=0.77 | c=0.77 |

*** p <.0001, ** p <.01, * p <.05

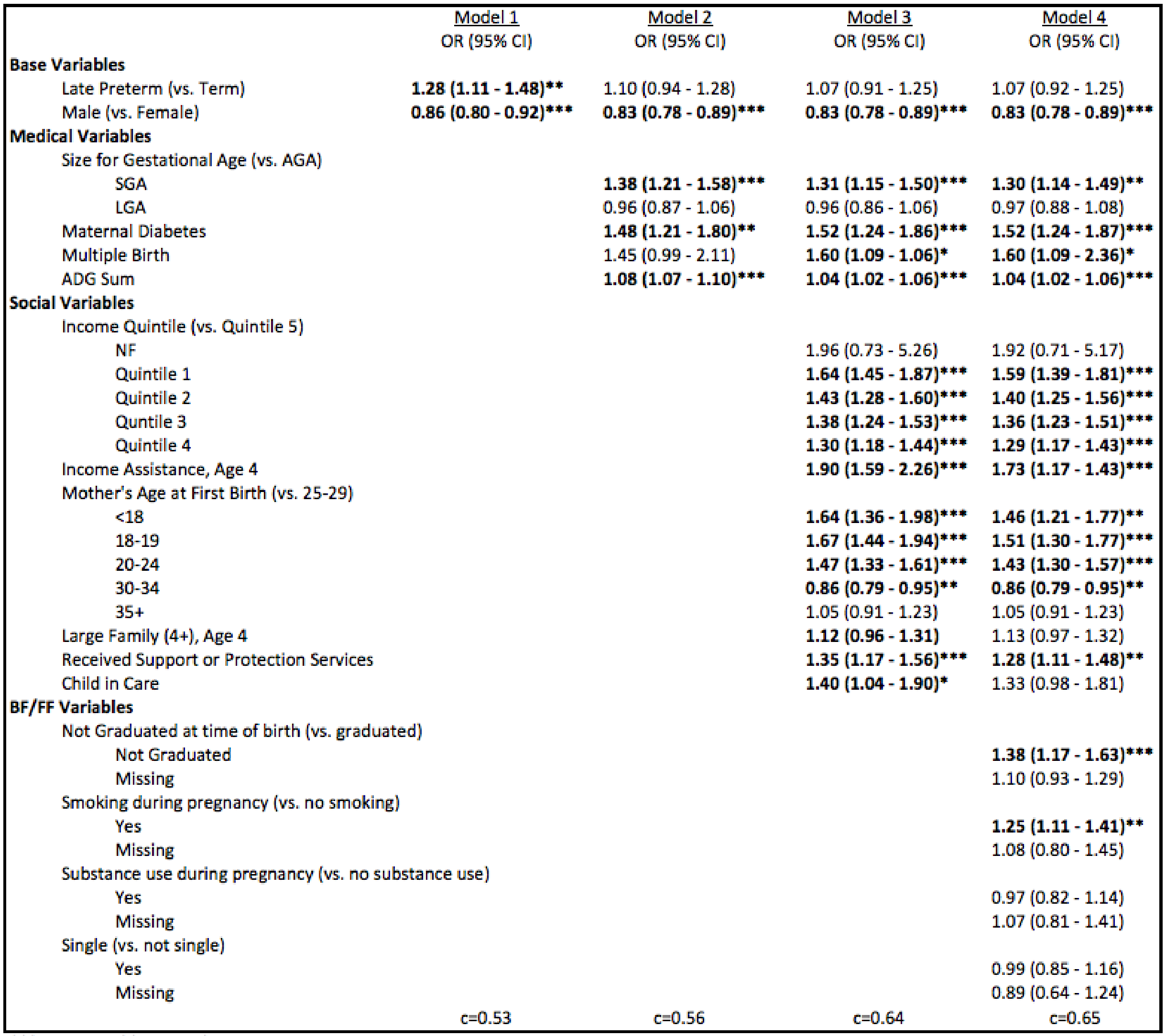
Table B15: Logistic Regression of not meeting or approaching expectations in grade 3 reading assessments with BF/ FF Variables (n=18,275)



| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) | Model 4<br>OR (95% CI) |
|---|---|---|---|---|
| **Base Variables** | | | | |
| Late Preterm (vs. Term) | 1.26 (1.11 - 1.44)** | 1.09 (0.95 - 1.26) | 1.06 (0.91 - 1.23) | 1.06 (0.91 - 1.23) |
| Male (vs. Female) | 1.35 (1.27 - 1.45)*** | 1.32 (1.24 - 1.42)*** | 1.36 (1.27 - 1.46)*** | 1.37 (1.28 - 1.47)*** |
| **Medical Variables** | | | | |
| Size for Gestational Age (vs. AGA) | | | | |
| SGA | | 1.30 (1.15 - 1.47)*** | 1.23 (1.09 - 1.40)** | 1.22 (1.08 - 1.39)** |
| LGA | | 0.99 (0.90 - 1.10) | 0.98 (0.88 - 1.09) | 1.00 (0.90 - 1.11) |
| Maternal Diabetes | | 1.43 (1.20 - 1.71)*** | 1.49 (1.24 - 1.79)*** | 1.49 (1.24 - 1.79)*** |
| Multiple Birth | | 1.40 (1.01 - 1.94)* | 1.53 (1.08 - 2.16)* | 1.53 (1.08 - 2.17)* |
| ADG Sum | | 1.08 (1.06 - 1.10)*** | 1.02 (1.01 - 1.04)* | 1.02 (1.00 - 1.04)* |
| **Social Variables** | | | | |
| Income Quintile (vs. Quintile 5) | | | | |
| NF | | | 1.76 (0.86 - 3.63) | 1.68 (0.82 - 3.48) |
| Quintile 1 | | | 1.97 (1.74 - 2.23)*** | 1.89 (1.67 - 2.14)*** |
| Quintile 2 | | | 1.67 (1.49 - 1.87)*** | 1.63 (1.46 - 1.83)*** |
| Quntile 3 | | | 1.49 (1.34 - 1.67)*** | 1.47 (1.32 - 1.64)*** |
| Quintile 4 | | | 1.35 (1.21 - 1.51)*** | 1.35 (1.21 - 1.50)*** |
| Income Assistance, Age 4 | | | 1.74 (1.52 - 1.99)*** | 1.55 (1.34 - 1.78)*** |
| Mother's Age at First Birth (vs. 25-29) | | | | |
| <18 | | | 1.71 (1.46 - 2.01)*** | 1.52 (1.28 - 1.79)*** |
| 18-19 | | | 1.63 (1.43 - 1.86)*** | 1.47 (1.28 - 1.69)*** |
| 20-24 | | | 1.41 (1.28 - 1.55)*** | 1.36 (1.24 - 1.50)*** |
| 30-34 | | | 0.83 (0.75 - 0.93)** | 0.84 (0.76 - 0.93)** |
| 35+ | | | 0.87 (0.74 - 1.03) | 0.88 (0.74 - 1.03) |
| Large Family (4+), Age 4 | | | 1.41 (1.23 - 1.61)*** | 1.42 (1.24 - 1.63)*** |
| Received Support or Protection Services | | | 1.43 (1.27 - 1.62)*** | 1.35 (1.19 - 1.53)*** |
| Child in Care | | | 1.05 (0.85 - 1.31) | 1.00 (0.81 - 1.25) |
| **BF/FF Variables** | | | | |
| Not Graduated at time of birth (vs. graduated) | | | | |
| Not Graduated | | | | 1.28 (1.12 - 1.47)** |
| Missing | | | | 1.27 (1.09 - 1.49)** |
| Smoking during pregnancy (vs. no smoking) | | | | |
| Yes | | | | 1.22 (1.10 - 1.36)** |
| Missing | | | | 1.05 (0.79 - 1.40) |
| Substance use during pregnancy (vs. no substance use) | | | | |
| Yes | | | | 0.88 (0.75 - 1.02) |
| Missing | | | | 1.14 (0.87 - 1.47) |
| Single (vs. not single) | | | | |
| Yes | | | | 1.19 (1.04 - 1.36)* |
| Missing | | | | 0.91 (0.67 - 1.24) |
| | c=0.54 | c=0.57 | c=0.67 | c=0.67 |

*** p <.0001, ** p <.01, * p <.05

Table B16: Logistic Regression of not meeting or approaching expectations in grade 3 numeracy assessments with BF/FF variables (n=14,763)



| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) | Model 4<br>OR (95% CI) |
|---|---|---|---|---|
| **Base Variables** | | | | |
| Late Preterm (vs. Term) | __1.28 (1.11 - 1.48)**__ | 1.10 (0.94 - 1.28) | 1.07 (0.91 - 1.25) | 1.07 (0.92 - 1.25) |
| Male (vs. Female) | __0.86 (0.80 - 0.92)***__ | __0.83 (0.78 - 0.89)***__ | __0.83 (0.78 - 0.89)***__ | __0.83 (0.78 - 0.89)***__ |
| **Medical Variables** | | | | |
| Size for Gestational Age (vs. AGA) | | | | |
| SGA | | __1.38 (1.21 - 1.58)***__ | __1.31 (1.15 - 1.50)***__ | __1.30 (1.14 - 1.49)**__ |
| LGA | | 0.96 (0.87 - 1.06) | 0.96 (0.86 - 1.06) | 0.97 (0.88 - 1.08) |
| Maternal Diabetes | | __1.48 (1.21 - 1.80)**__ | __1.52 (1.24 - 1.86)***__ | __1.52 (1.24 - 1.87)***__ |
| Multiple Birth | | 1.45 (0.99 - 2.11) | __1.60 (1.09 - 1.06)*__ | __1.60 (1.09 - 2.36)*__ |
| ADG Sum | | __1.08 (1.07 - 1.10)***__ | __1.04 (1.02 - 1.06)***__ | __1.04 (1.02 - 1.06)***__ |
| **Social Variables** | | | | |
| Income Quintile (vs. Quintile 5) | | | | |
| NF | | | 1.96 (0.73 - 5.26) | 1.92 (0.71 - 5.17) |
| Quintile 1 | | | __1.64 (1.45 - 1.87)***__ | __1.59 (1.39 - 1.81)***__ |
| Quintile 2 | | | __1.43 (1.28 - 1.60)***__ | __1.40 (1.25 - 1.56)***__ |
| Quntile 3 | | | __1.38 (1.24 - 1.53)***__ | __1.36 (1.23 - 1.51)***__ |
| Quintile 4 | | | __1.30 (1.18 - 1.44)***__ | __1.29 (1.17 - 1.43)***__ |
| Income Assistance, Age 4 | | | __1.90 (1.59 - 2.26)***__ | __1.73 (1.17 - 1.43)***__ |
| Mother's Age at First Birth (vs. 25-29) | | | | |
| <18 | | | __1.64 (1.36 - 1.98)***__ | __1.46 (1.21 - 1.77)**__ |
| 18-19 | | | __1.67 (1.44 - 1.94)***__ | __1.51 (1.30 - 1.77)***__ |
| 20-24 | | | __1.47 (1.33 - 1.61)***__ | __1.43 (1.30 - 1.57)***__ |
| 30-34 | | | __0.86 (0.79 - 0.95)**__ | __0.86 (0.79 - 0.95)**__ |
| 35+ | | | 1.05 (0.91 - 1.23) | 1.05 (0.91 - 1.23) |
| Large Family (4+), Age 4 | | | __1.12 (0.96 - 1.31)__ | 1.13 (0.97 - 1.32) |
| Received Support or Protection Services | | | __1.35 (1.17 - 1.56)***__ | __1.28 (1.11 - 1.48)**__ |
| Child in Care | | | __1.40 (1.04 - 1.90)*__ | 1.33 (0.98 - 1.81) |
| **BF/FF Variables** | | | | |
| Not Graduated at time of birth (vs. graduated) | | | | |
| Not Graduated | | | | __1.38 (1.17 - 1.63)***__ |
| Missing | | | | 1.10 (0.93 - 1.29) |
| Smoking during pregnancy (vs. no smoking) | | | | |
| Yes | | | | __1.25 (1.11 - 1.41)**__ |
| Missing | | | | 1.08 (0.80 - 1.45) |
| Substance use during pregnancy (vs. no substance use) | | | | |
| Yes | | | | 0.97 (0.82 - 1.14) |
| Missing | | | | 1.07 (0.81 - 1.41) |
| Single (vs. not single) | | | | |
| Yes | | | | 0.99 (0.85 - 1.16) |
| Missing | | | | 0.89 (0.64 - 1.24) |
| | c=0.53 | c=0.56 | c=0.64 | c=0.65 |

*** p <.0001, ** p <.01, * p <.05