HISPANIC PARADOX IN NORTH CAROLINA: EXPLORING THE FAVORABLE BIRTH WEIGHT PROFILE OF CHILDREN BORN TO FOREIGN BORN HISPANIC MOTHERS

Samuel H. Fishman

A thesis submitted to the faculty at the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Masters of Arts in the sociology department in the school of liberal arts and sciences.

Chapel Hill
2016

Approved by:

S. Philip Morgan

Robert A. Hummer

Kathleen M. Harris

ABSTRACT

Samuel H. Fishman: Hispanic Paradox in North Carolina: Explaining the Favorable Birth Weight Profile of Children Born to Foreign Born Hispanic Mothers
(Under the direction of S. Philip Morgan)

Much research finds that Hispanic Americans have similar health outcomes to non-Hispanic white Americans despite facing discrimination and having relatively low socioeconomic statuses. In the context of this "Hispanic Paradox", this paper documents the effects of race and ethnicity on birth weight in North Carolina, exploring several maternal health behaviors and conditions that could account for the favorable birth outcomes of Hispanics (vis-à-vis other groups). I use data from the North Carolina Birth Certificates, information on 901,873 first parity, singleton births between 1990 and 2009. While previous research finds similar rates of low birth weight among Hispanics and non-Hispanic whites, my research finds that foreign born Hispanic mothers have a lower risk of low, very low, and high birth weight than do non-Hispanic white mothers. Foreign born Hispanic mothers' favorable birth weight profile stems from longer pregnancies and lower rates of prenatal smoking relative to non-Hispanic white mothers.

ACKNOWLEDGEMENTS

S. Philip Morgan provided advice throughout the writing process. Chris Glessner's master's thesis (2014) used Cox Proportional Hazards regression to measure gestational age. I used this model for my second analysis. Ken Bollen provided advice on gestational age measurement error. Jennifer Buher-Kane's IRB provided me with the birth certificate data used in my research. Robert A. Hummer and Kathleen Mullan Harris provided edits on late drafts.

TABLE OF CONTENTS

List of Tables and Figures…VI

Introduction… 1

Birth Weight Paradox and Acculturation… 2

Data… 12

Methods and Results…14

Discussion… 27

Conclusion… 29

Appendix A… 32

References… 34

LIST OF TABLES

Table 1: Continuous and Categorical Variables…………………………………………………14

Table 2: Prenatal Smoking, Education Diabetes, and Birth Weight by Mother's Race/Ethnicity…..15

Table 3: Live Births Remaining Unborn at Gestational Age (weeks) by Maternal Race/Ethnicity…16

Table 4: Maternal Race/Ethnicity and Year of Birth……………………………………………17

Table 5: Multinomial Logit Model: Birth Weight Categories……………………………………..21

Table 6: Cox Proportional Hazard Model: Gestational Age at Birth……………………………….25

Table 7: Multinomial Logit Model: Birth Weight Categories using Predicted Probabilities………...33

List of Figures

Figure 1: Conceptual Model of Birth Weight Factors…………………………………………...............5

LIST OF ABBREVIATIONS

BW	Birth Weight
HBW	High Birth Weight
HR	Hazard Ratio
LBW	Low Birth Weight
RRR	Relative Risk Ratio
SE	Standard Error
VLBW	Very Low Birth Weight

INTRODUCTION

The "Hispanic Paradox" refers to Hispanics' equal or superior health outcomes vis-à-vis whites in the United States and their clearly superior health outcomes compared to U.S. Blacks. This finding surprises public health researchers and social scientists given Hispanics' similar socioeconomic statuses and educational attainment levels to U.S. Blacks (Markides and Coreil 1986). A large body of research addresses the question: why are the health outcomes of Hispanics relatively "favorable"?

Some prior research documents more positive health outcomes for Hispanics (vis-à-vis non-Hispanic whites) in a variety of populations and for a variety of health outcomes (Hummer et al. 2007; Markides and Eschbach 2005; Turra and Goldman 2007; Powers 2013); other analyses find similar or worse health outcomes for Hispanics (vis-à-vis non-Hispanic whites) (Smith and Bradshaw 2006; Crimmins et al. 2007; Hunt et al. 2003). There is agreement, however, that Hispanic Americans have relatively positive health outcomes when compared to U.S. Blacks.

There is active debate on the reasons for the Hispanic Paradox. Some argue that Hispanics' apparent health advantages are artifacts of inaccurate data. Others point to selection bias, i.e., immigration may select particularly healthy individuals. Alternatively, a "Salmon Bias" has been proposed -- the return of older individuals in poor health to their home country could produce the Hispanic Paradox findings related to adult morbidity and mortality. Finally, the Hispanic Paradox may be driven by healthy behaviors rooted in Hispanic immigrants' culture (cultural buffering) (Palloni and Arias 2004). Cumulative evidence suggests that selectivity on healthy immigrants is the most reasonable explanation for the Hispanic Paradox; this finding is replicated among other immigrant groups of non-Western origins in Canada and Australia (Markides and Eschbach 2011). For the purposes of my paper, I assume that Hispanic Paradox in birth weight is due to immigrant selectivity.

My paper examines several maternal health mechanisms for the Hispanic birth weight Paradox, addressing several questions. First, do Hispanics in North Carolina have a favorable birth weight profile relative to non-Hispanic whites? Second, if so, which prenatal health mechanisms are responsible for Hispanics' favorable birth weight profile?

Previous research finds that the Hispanic Paradox is more visible for foreign-born Hispanics than for those who were U.S. born. Thus, my research distinguishes between the children of foreign born Hispanic mothers and native born Hispanic mothers. I expect that foreign born Hispanic mothers have relatively low risk of adverse birth weight due to their low rates of prenatal smoking and gestational diabetes. Smoking not only impacts birth weight by impeding intrauterine growth; it also operates through gestational age by decreasing rates of preterm births. Foreign born Hispanic mothers' relatively low rates of negative prenatal health behaviors and conditions offset their lower socioeconomic status. As a result they have a favorable birth weight profile relative to non-Hispanic white and U.S. born Hispanic mothers.

The Birth Weight Paradox and Acculturation

This paper examines the Hispanic Paradox in North Carolina using adverse birth weight as a measure of infant health. Past research finds similar rates of low birth weight among Hispanics relative to those of non-Hispanic whites (Acevedo-Garcia et al. 2007; Leslie et al. 2003; Hesson and Fuentes-Afflick 2000; Fuentes-Afflick et al. 1999; Fuentes-Afflick and Lurie 1997); this relatively favorable birth weight profile is considered an instance of "Hispanic Paradox."

Like non-Hispanic blacks in the U.S., Hispanics experience harmful discrimination and socioeconomic disadvantage (Lariscy et al. 2015; Pew 2011; Arujo and Borrell 2006). Prior research finds that chronic stress from discrimination and disadvantaged socioeconomic status are associated with less favorable birth outcomes, including adverse birth weight (Strutz et al. 2012; Lauderdale 2006; Kramer 1987). However, unlike non-Hispanic blacks who consistently experience higher rates of adverse birth weight (Martin et al. 2013), Hispanics have similar rates of low birth weight relative to non-Hispanic whites (hence, the "Paradox"). Prior research on Hispanic Paradox in North Carolina finds that Hispanics have similar rates of low birth weight, premature birth, and infant mortality to those of non-Hispanic whites (Leslie et al. 2003).

Consistent with the hypothesis on healthy immigrant selectivity (Palloni and Arias 2004), past research finds that time spent living in the U.S. among Hispanic Americans is associated with less favorable birth outcomes (Markides and Eschbach 2011). Using national level vital statistics data, researchers find that foreign born status is associated with lower rates of low birth weight than Hispanic mothers who are born in the U.S., particularly among those of lower levels of education (Acevedo-Garcia et al. 2005; Acevedo-Garcia et al. 2007). This finding may be due to changes in health behavior that occur with time spent in the United States; for example, foreign born Hispanics have healthier diets than those born in the U.S. (Guendelman and Adams 1995). Similarly, lack of tobacco advertising targeting at Hispanics was associated with low rates of smoking; rates of smoking among Hispanics began to dramatically rise during the late 1980s (Tye et al. 1987). Previous literature on birth weight finds that Hispanic Americans have relatively low rates of adverse birth weight, confirming the "Paradox." This effect is stronger for foreign born Hispanics than for those born in the U.S., likely due to accumulation of negative health behaviors common in the U.S among U.S. born Hispanics.

One key mechanism for the birth weight Paradox may be pregnancy length. Prior research finds that Mexican Americans' low rates of low birth weight are due to reduced rates of preterm births relative to non-Hispanic white mothers. Buekens et al. suggests that future research on low birth weight among Hispanics examine gestational age and preterm births as the proximate mechanism for birth weight (2000). I use survival models to further examine potential mechanisms for foreign born Hispanic mother's longer pregnancies.

Fuentes-Afflick et al.'s (1999) research on Hispanic Paradox using California birth certificates (1992) distinguishes four categories of birth weight: very low (500-1,499 grams), low (1,500-2,499 grams), healthy (2,500-3,999 grams)and high birth weight (>4,000 grams). Their research demonstrates the merit of differentiating low and very low birth weight as they find that Hispanics have lower rates of very low birth weight; they also have slightly higher rates of low birth weight in comparison with the children of non-Hispanic white mothers. However, they leave high birth weight unexamined. I adopt the Fuentes-Afflick et al.'s measurement strategy and extend on previous research in several ways.

First, I estimate models that sequentially add control variables and mediators to determine the mechanisms that produce adverse birth weight and to differentiate between low birth weight caused by preterm birth from that caused by restricted intrauterine growth.[1] I propose a conceptual model (see Figure 1) to display the mechanisms for Hispanic birth weight Paradox. Foreign born Hispanic mother's favorable birth weight profile (relative to non-Hispanic whites and U.S. born Hispanics) stems from low rates of prenatal smoking and gestational diabetes. Low rates of smoking lead to decreased risk of adverse birth weight and concurrently lead to longer pregnancies. I anticipate that foreign born Hispanic mothers' longer pregnancies are also driven by unmeasured factors. In turn, longer pregnancies decrease the risk of adverse birth weight. In summary, I expect that foreign born Hispanic's favorable birth weight profile is largely mediated by three mechanisms: prenatal smoking, gestational diabetes, and pregnancy length.[2]

[1] Fuentes-Afflick et al. (1999) only includes bivariate and "preferred" models.

[2] Other mechanisms for the Hispanic birth weight Paradox, such as diet, are unmeasured in my analysis.

Second, as previously mentioned, I adopt Fuentes-Afflick et al.'s birth weight measurement strategy; allowing us to differentiate very low and low birth weight and explore mechanisms for high birth weight. Third, my research provides more than an additional decade of data to the only other study of the birth weight "Paradox" in North Carolina (Leslie et al. 2003).

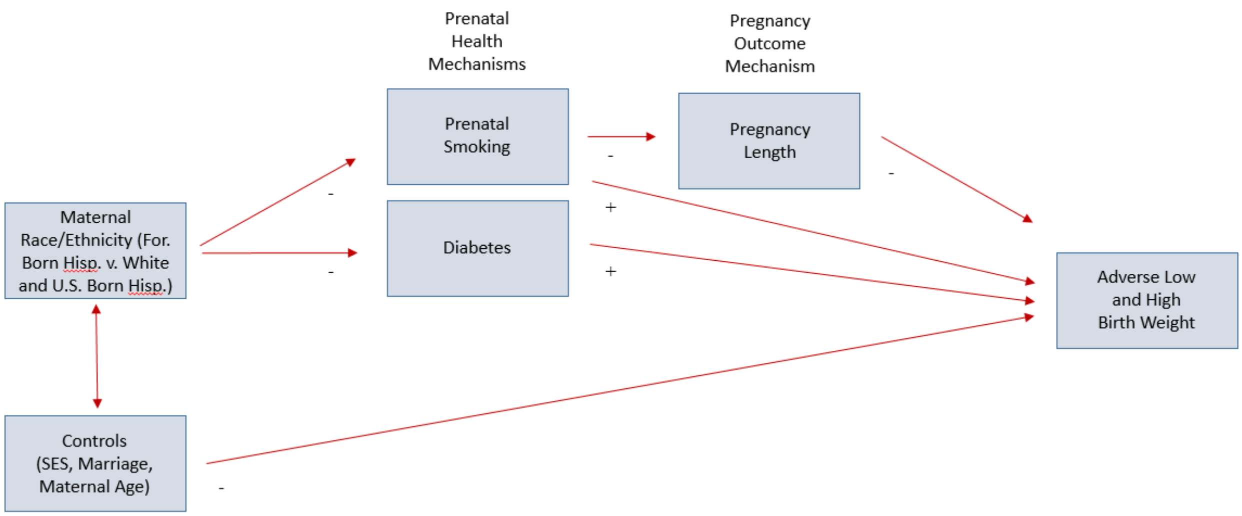

Figure 1: Conceptual Model of Birth Weight Factors

Establishing Context: North Carolina and Birth Weight Trends over Time

North Carolina is the tenth most populous state in the U.S. and is demographically diverse with a substantial Hispanic population. In 2011 an estimated 828,000 Hispanics lived in North Carolina, accounting for 9 percent of the population (Pew 2011). Hispanics in North Carolina are economically disadvantaged with annual median personal earnings of $17,200 for individuals who are age 16 or older.[3] Hispanics account for 15 percent of all births in North Carolina. The majority of Hispanics in North Carolina are of Mexican descent (58%) (Pew 2011). As I will document, foreign-born Hispanic mothers contribute a larger proportion of North Carolinian births in more recent years.

[3] Non-Hispanic Whites and non-Hispanic blacks have annual median personal earnings of $30,000 and $22,000, respectively (Pew 2011).

Hispanic immigration to North Carolina began with Mexican farm laborers arriving in the early 1980s. In the mid-1980s Mexicans began to work in rural (poultry processing and meatpacking) and urban (manufacturing, construction, landscaping, nurseries, restaurant, and hospitality) jobs. Mexicans have largely replaced African American factory and rural labor. Since the passing of the Immigration Reform and Control Act of 1986, immigration to North Carolina has substantially grown (Durand et al. 2005).

Hispanic immigration to North Carolina exploded between 1990 and 2000, with a massive 396 percent increase in Hispanic population, occurring in both urban and rural areas. This recent wave of Hispanic immigration to North Carolina is part of a larger trend of immigration to Southeast U.S (Kandel and Parrado 2006).

Previous research on the Hispanic birth weight Paradox uses data from older Hispanic immigrant destinations such as California (Fuentes-Afflick et al. 1999; Fuentes-Afflick et al. 1998; Hessol and Fuentes-Afflick 2000) and nationally representative sources (Fuentes-Afflick and Lurie 1997; Acevedo-Garcia et al. 2007). In contrast with this past research, my research (alongside Leslie et al. 2003) examines this phenomenon in the Southeast U.S., capturing immigration trends from a recent destination for Hispanic immigrants.

Despite the considerable body of literature on the Hispanic Paradox and birth weight, past literature may be outdated. A recent national vital statistics report (Martin et al. 2013) shows that rates of low birth weight by race/ethnicity have shifted since 1990, with Hispanics (relative to non-Hispanic whites) having less favorable outcomes in 1990, more favorable outcomes in 2006, and less favorable outcomes again in 2013. Building on Leslie et al.'s (2003) past work on birth weight Paradox in North Carolina in the mid 1990's, my analysis is sensitive to changes over a two decade period (1990-2009).

Mechanisms for Adverse Birth Weight

My paper's primary contribution to the literature on Hispanic Paradox is its examination of mechanisms for Hispanic's relatively healthy birth weight profile. Through iterative regression analysis, I examine mechanisms for Hispanic Paradox using my hypothesized conceptual model (see Figure 1). Adopting a more refined birth weight measurement strategy allows for more effective analysis of mechanisms for adverse birth weight than previous research on the birth weight "Paradox," which use a binary variable (low and non-low birth weight). Notably, my analysis examines high birth weight as a category of adverse birth weight with distinct mechanisms.

Adverse low birth weight is defined clearly in previous medical and public health literature. The World Health Organization defines infants below 2,500 grams (5.5 pounds) at birth as having a low birth weight. Infants below 1,500 grams (3.3 pounds) are considered to have a very low birth weight (Kramer 1987; Fuentes-Afflick 1999; Strutz et at. 2012). Low birth weight can be caused by restricted intrauterine growth or by preterm birth (Frisbie 2005; Kramer 1987). My research examines both types of low birth weight.

While arbitrary in an absolute sense these distinctions are strongly predictive of health problems – in both the short and long term. Infants with low birth weight have higher risk of impaired growth, morbidity, brain damage, lung disease, liver disease, learning impairment, and asthma than those of non-low birth weight (Shiono and Behrman 1995; Child Trends 2015). Moreover, alongside gestational age and maturity of the infant, birth weight is one of the proximate determinants of infant mortality and child morbidity. Most commonly, length of gestation impacts on birth weight, which in turn influences the risk of infant mortality (Frisbie 2005). Infants at very low birth weight are at greatly increased risk of health complications than those of moderately low birth weight (Child Trends 2015); in fact, most infant deaths occur to very low birth weight infants (Frisbie 2005). In 1988, 13 percent of all births were low birth weight. The costs of health care, childcare, and education for 3.5 to 4 million children who were born at a low birth weight accounted for between $5.5 to $6 billion more than if these children were born with a healthy birth weight. Furthermore, care for children with low birth weight accounted for 10% of all spending on health care for children in the United States in 1988 (Lewit et al. 1995). More recent research from the 2001 Healthcare Cost and Utilization Project found that half of infant hospitalization and one quarter of pediatric costs were due to preterm and/low birth weight infants (Russell et al. 2007).

Most previous research on the Hispanic birth weight Paradox utilizes binary terms for birth weight (low birth weight and non-low birth weight) (Cobas et al. 1995; Fuentes-Afflick and Lurie 1997; Hessel and Fuentes-Afflick 2000; Frank and Hummer 2002; Chung et al. 2003; Acevedo-Garcia et al. 2005; Acevedo-Garcia et al. 2007). The dichotomization of birth weight fails to measure the difference between very low birth weight (< 1,500 grams) and low birth weight (1,500-2,500 grams), categories of birth weight with very different levels of health risk (Strutz et al. 2012; Schieve et al. 2002; Kleinman and Kessel 1987).

Although research on birth weight primarily examines low birth weight, recent research finds that high birth weight is also associated with health risks. Children with high birth weight have an increased risk of later life obesity (Curhan et al. 1996; Deckelbaum et al. 2001; Gillman et al. 2003). High birth weight also increases the risk of labor complications, Cesarian birth, chorioamnionitis, shoulder dystocia, fourth-degree lacerations, postpartum hemorrhage, prolonged hospital stay, and neonatal morbidity (Boulet et al. 2003; Stotland et al. 2003). Some researchers categorize births over 4,000 grams to be of high birth weight (Fuentes-Afflick et al. 1999; Strutz et al. 2012; Wei et al. 2003); others use 4,500 grams as a cut-off (Lipscomb et al. 2005; Berard et al. 1998; Nassar et al. 2003; Boulet et al. 2003).

High pre-pregnancy weight and height, parities greater than 2, longer pregnancies, and male gender are associated with increased risk of high birth weight. Prenatal smoking is associated with a decreased risk of high birth weight (Ørskou et al. 2003; Shrutz et al. 2012). Notably, gestational diabetes mellitus is associated with increased risk of high birthweight (Xiong et al. 2001; Gillman et al. 2003; Naver et al. 2013). I hypothesize that gestational diabetes serves as a measurable mechanism through which foreign born Hispanics have decreased risk of high birth weight (see Figure 1).

Prenatal maternal smoking is strongly associated with increased risk of low birth weight and preterm births (Frisbie 2005; Chomitz, Cheung, and Lieberman 1995; Lundsberg, Bracken, and Saftlas 1997; Brooke et al. 1989; Cnattingius et al. 1993). Lower rates of smoking among Hispanics may serve as a mediator for lower rates of low birth weight and preterm birth (Leslie et al. 2013). Lower rates of smoking among Hispanics may be due to lack of tobacco advertising among Hispanic populations (Tye et al. 1987). I predict that prenatal smoking serves as a mechanism through which foreign born Hispanics have decreased risk of very low and low birth weight (see Figure 1).

Birth weight is directly dependent on the time period a child is in gestation. Gestational age is usually measured in weeks; preterm birth is usually considered to be earlier than 37 weeks. 32, 33, or 34 weeks are frequently used as a benchmark for very preterm births (Berkowitz and Papiernik 1993). As previously mentioned, preterm birth infants have lower birth weights than non-preterm birth infants. This difference in weight is caused by the loss of time for intrauterine growth. Adding a variable for gestational age allows statistical models to differentiate between preterm births and low birth weight for gestational age (Frisbie 2005; Kramer 1987).

Rates of preterm birth vary by racial and ethnic background. The children of black mothers have much higher risk of preterm birth than white mothers in the U.S. and U.K. In contrast, the children of Hispanic mothers have relatively low rates of preterm birth (Goldenberg et al. 2008). Previous medical research from North Carolina finds that the children of Hispanic women are less likely to have preterm births than the children of white and African American mothers (Brown et al. 2007). Gestational age may serve as a partial proximate mediator through which smoking may impede birth weight (see Figure 1). Gestational age may also act as a proximate mediator of low birth weight for other unspecified health mechanisms (Buekens et al. 2000). Likewise, longer pregnancy length may serve as an influential mediator (acting independent of smoking) between Hispanic race/ethnicity and reduced risk of low birth weight (see Figure 1).

Like birth weight, pregnancy length is impacted by other proximate health mechanisms. Prenatal smoking is associated with preterm birth, likely operating through nicotine and carbon monoxide or increased inflammation which can cause spontaneous birth (Goldenberg et al. 2008). Likewise, gestational diabetes mellitus is associated with an increased risk of preterm birth as increased rates of glycaemia are associated with spontaneous early birth (Hedderson et al. 2003). Relatively low rates of prenatal smoking and gestational diabetes among foreign born Hispanics likely serve as mechanisms for longer gestational period vis-à-vis non-Hispanic whites.

Socioeconomic status affects birth weight through other mediating factors such as nutrition, infectious diseases, or exposure to toxins (Frisbie 2005; Kramer 1987). Increased level of maternal education is associated with decreased risk of low birth weight. Maternal education level can serve as a proxy for socioeconomic status. However, education also has an independent impact on birth weight that operates outside of socioeconomic status (Victoria et al. 1992; Luo et al. 2006).

As Hispanics in the United States have low socioeconomic status in comparison with non-Hispanic whites (Pew 2011), it is expected that these conditions would put them at increased risk of adverse birth weight outcomes. My research will control for socioeconomic status through the proxy of maternal education (see Figure 1).

Foreign born Hispanics in North Carolina over the age of 15 have higher rates of marriage (49%) than Hispanics born in the U.S. (34%) and blacks (31%), but have much lower rates than whites (56%). Previous research finds that infants born to unwed mothers are at increased risk of low birth weight (Frisbie 2005). I will control for marriage at time of birth using a dummy variable.

Advanced and early maternal age are associated with increased risk of low birth weight (Lee et al. 1988). Additionally, advanced maternal age is associated with increased risk of preterm birth (Joseph et al. 2005). Women's fecundity begins to decline in their 20s; this decline accelerates in their late 30s (Dunson et al. 2002). However, older maternal age is also beneficial as it is associated with greater socioeconomic status (Stein and Susser 2000). Past research consistently finds U-shaped relationships between maternal age and infants' health. Maternal age has a U-shaped relationship with low birth weight and preterm birth (Abel et al. 2002), infant mortality (Frisbie 2005; Misra and Ananth 2002), and congenital malformations (Croen and Shaw 1995). Recent Hispanic immigrants are often in the early 20s (Palloni and Arias 2004) and have high intensity periods of fertility following immigration (Parrado 2011). I expect that foreign born Hispanics' relatively young maternal age at first birth is associated with increased risk of adverse birth weight (due to socioeconomic disadvantage) (see Figure 1). I control for maternal age and include an additional variable for maternal age squared in order to model the U-shaped relationship between maternal age and child's health.

I only examine first parity births in my paper as birth order impacts birth weight. Birth weight increases after parity one. However, birth weight may decrease with higher parity births (Kramer 1987). Foreign born Hispanic mothers may be more likely to have low parity births as many recent Hispanic immigrants to the U.S. have high intensity periods of fertility in their post migration period (Parrado 2011). The relatively young age of these immigrants (Palloni and Arias 2004) further contributes to an increased probability of low parity births.

Adding to the problem of parity, births are clustered within mothers. Because de-identified birth certificates do not link births to mothers, I am unable to account for similarity between births to the same mother. For example, it is likely that mothers who give birth to low birth weight children at first parity have increased risk of low birth weight in later parities compared to a mother who has a child at a healthy, heavier birth weight. Using only first parity births counteracts this threat of autocorrelation between births of the same mother and controls for parity's impact on birth weight. This exclusion has an additional benefit; mothers are most similar at first parity as complications from previous pregnancies (such as C-section births) do not influence mothers and children's health.

Period effects are particularly important for foreign born Hispanics as the flow of Hispanic immigration changes over time, with clustering in specific periods (Durand et al 2000; Durand et al. 2001). In turn, these specific periods may be associated with phenomena or trends that influence birth weight. In order to account for time trend and period effects my models include fixed effects for year of birth.[4]

Data

My research uses de-identified data from North Carolina birth certificates (1990-2009), obtained from the North Carolina Center for Health Statistics. Cases with missing data were eliminated using list-wide deletion due to the small number of missing cases (less than 1%). Responses with gestational age at birth greater than 44 weeks or less than 22 weeks were removed. These cut-points were selected because previous research on gestational age distributions consider week 22-23 to be the first age of viability (Kramer et al. 2001; Breborowicz 2001); these distributions generally cut off at week 43-44 (Kramer et al. 2001; Davidoff et al. 2006). Of the original 2,265,326 cases, 2,163,923 cases remained after list-wide deletion and the removal of unrealistic early births. Non-singleton and

[1] Births at 40-44 weeks of gestational age have decreased in recent years. Simultaneously, there have been increases in births between 37-39 weeks and 34-36 weeks. These changes are observed across all categories of delivery (Davidoff et al. 2006).

non-first parity births were also removed from the dataset. Additionally, Asian and mothers of "Other" race were removed from the data because of the focus on the Hispanic Paradox (and the contrast with non-Hispanic whites and Blacks). After these restrictions 901,873 cases remained.[5]

The outcome variable is birth weight, recorded in grams in the birth certificate data. A medical professional present at a birth records the child's weight immediately after birth. Measurements of birth weight in the North Carolina birth certificates are highly reliable (Vinikoor et al. 2010).

As noted above, birth weight in grams was converted into four categories of birth weight: Very low birth weight (<1,500 g), low birth weight (1,500-2499 g), healthy birth weight (2,500-4,499), and high birth weight (>4,500 g). This categorization is similar to previous variables used to measure the effects of maternal body mass on children's birth weight (Strutz et al. 2012; Fuentes-Afflick et al. 1999).[6]

Maternal race and ethnicity is divided into four categories, non-Hispanic white, non-Hispanic black, U.S. born Hispanic, and foreign born Hispanic. This variable was constructed from variables on race, Hispanic identification, and Hispanic mothers' birth place (U.S. or foreign). Despite the heterogeneity among Hispanic backgrounds and places of origin, I use Hispanic identity as a mutually exclusive category in my analysis. Variables for race not only measure one's racial/ethnic self-identification, they also encapsulate the cumulative social experiences of a person of this group.

[5] Unrealistic birth weights were not removed from the data because no cases appeared to be outliers. Also, the exclusion of the top .01 percent and bottom .01 percent of birth weight had no impact on the results.

[6] My categorization uses a higher weight threshold (4,500 grams) than Strutz et al. (2012) and Afflick et al. (1999) (4,000 grams) for high birth weight in order to more clearly differentiate between birth weights that are large due to high height and weight of mothers (and hence not necessarily unhealthy) and birth weights that are high and detrimental to maternal and child health.

The variable for prenatal smoking has four categories: non-smoker, 1-10 cigarettes per day, 11-20 cigarettes per day, and more than 20 cigarettes per day. Multiple categories are used to measure smoking because non-smokers are qualitatively different in health from individuals who smoke any number of cigarettes. Reported prenatal smoking rates may be driven down by social desirability bias, thus reducing statistical power. The dummy variable for diabetes indicates which mothers had gestational diabetes mellitus during their pregnancy. The variable for gestational age measures the length of time between conception and birth in weeks. This variable is kept in its original interval-ratio form.[7] Education was broken into fmy categories based on years spent in school: less than high school degree (<8 years), high school degree (12 years), some college (>12 and <16), and bachelor's degree or more (≥16). The variable for marriage indicates whether or not the mother was married at the time of birth.

Methods and Results

Descriptive Results

A small but substantial percentage of first births in North Carolina are very low (1.6%) or low (6.5%) birth weight (8.1% when added together) (see Table 1); this finding is in line with the national average (for births of all parities) in 2006 (8.3%) and slightly above national average in 1990 (7%) (Martin et al. 2013). Approximately 1.2 percent of births are high birth weight (1.16%, see Table 1). The majority of the births are to non-Hispanic white mothers (66.7%); however a substantial percentage were to foreign born Hispanic mothers (7%). The modal education of first time mothers is high school (30.8%).

[7] Previous research finds that the last menstruation method of determining gestational age is subject to greater random error and overestimation in comparison with ultrasound (Savitz et al. 2002). However, researchers compared linked data from the North Carolina birth certificates and PIN (2000-2004, 2006 birth cohorts), a clinical study based on data from patients at University of North Carolina associated hospitals (Vinikoor et al. 2010). 91% of the women in PIN had their gestational age estimated by ultrasound (Savitz et al. 2012). This comparison finds a 98% agreement and a Spearman's Correlation of .9 between the cases of linked data (Vinikoor et al. 2010). Therefore, the measurement error is minimal and my models can utilize gestational age operating under the assumption of zero measurement error.

Table 1: Continuous and Categorical Variables

	Mean	Std. Dev.	Min	Max	Percent
Gestational Age at Birth (weeks)	39	2	22	44	
Birth Weight (grams)	3271	601	28	6549	
Maternal Age	24	6	10	55	
Year of Birth	2000	6	1990	2009	
Birth Weight Categories					
Very low					1.6
Low					6.5
Normal					90.8
High					1.2
Maternal Race/Ethnicity					
White					66.8
Black					24.5
U.S. born Hispanic					1.7
Foreign born Hispanic					6.9
Maternal Education					
No high school					21.5
High School					30.8
Associate's degree					22.0
Bachelor's degree					25.8
Prenatal Smoking					
Non-smoker					88.6
1 to 10					8.7
11 to 20					2.4
More than 20					0.3
Gestational Diabetes (yes)					2.4
Married at Time of Birth (yes)					59.3

N=901,873

Table 2 shows that over 99.6 percent of foreign born Hispanic mothers are non-smokers during the prenatal period. Smoking is much more prevalent among non-Hispanic white, non-Hispanic black, and U.S. born Hispanic mothers. Non-Hispanic white mothers have the highest rates of prenatal smoking with over 10.9 percent smoking 1-10 cigarettes per day, and 3.5 percent smoking 11-20 cigarettes per day. Maternal diabetes is the least prevalent among foreign born Hispanic mothers (1.9%); non-Hispanic white mothers are much more likely to have diabetes (2.6%). Notably, foreign born Hispanic women are of particularly low socioeconomic status; less than half have completed high school. Only 42.2 percent of these foreign born women are married at time of birth. U.S. born Hispanics' have much higher levels of education (29% with less than high school), and a higher percentage are married at time of birth (54.6%) relative to foreign born Hispanics. These findings on smoking, diabetes, and socioeconomic status are consistent with previous findings of "Hispanic Paradox" (Leslie et al. 2003; Lariscy et al. 2015) and my conceptual model (see Figure 1).

Table 2: Prenatal Smoking, Education, Diabetes, and Birth Weight by Mother's Race/Ethnicity (%)

	White	Black	U.S. Born Hisp.	For. Born Hisp.
Non-Smoker	85.3	93.8	95.4	99.6
1 to 10 Cig.	10.8	5.6	4.0	0.4
11 to 20 Cig.	3.4	0.6	0.6	0.0
More than 20 Cig.	0.4	0.1	0.1	0.0
No High School	14.4	28.4	29.0	63.4
High School	29.3	36.5	35.0	23.6
Associate's	23.7	21.5	21.7	7.3
Bachelor's	32.6	13.7	14.4	5.7
Diabetes (Yes)	2.6	2.3	2.2	1.9
Married (Yes)	74.8	22.3	54.6	42.2
VLBW	1.2	3.0	1.4	0.9
LBW	5.4	9.9	6.0	5.3
Healthy BW	92.0	86.6	91.7	93.0
High BW	1.4	0.5	0.9	0.8

N=901,873

Table 3 displays the percentage of live pregnancies that remain in gestation at specific weeks in pregnancy. The table shows that non-Hispanic black mothers have substantially earlier gestational age at birth than do other racial/ethnic groups as only 79.9 percent of pregnancies reach full term (i.e., 37 weeks). Gestational age at birth is nearly indistinguishable between non-Hispanic white mothers and U.S. born Hispanic mothers as 84.4 percent and 84 percent of their respective pregnancies reach full term. Notably, foreign born Hispanic mothers have a slightly lower rate of births between week 35 and 37 than non-Hispanic white and U.S. born Hispanic mothers. Their children are the most likely to reach full term (86.5 %). Once again these results are consistent with my conceptual model (see Figure 1) as increased gestational age at birth for foreign born Hispanics (in comparison with non-Hispanic whites) is likely associated with decreased risk of low birth weight.

Table 3: Live Births Remaining Unborn at Gestational Age (weeks) by Maternal Race/Ethnicity (%)

	White	Black	US Born Hisp.	For. Born Hisp.
30	99.0	97.3	98.7	99.2
31	98.7	96.8	98.5	98.9
32	98.3	96.1	98.0	98.6
33	97.7	95.2	97.5	98.1
34	96.7	93.8	96.4	97.2
35	94.9	91.8	94.6	95.7
36	91.4	87.7	91.1	92.7
37	84.5	80.1	84.0	86.6
38	71.2	65.4	69.4	72.3
39	48.6	42.7	44.4	47.7
40	17.0	13.8	15.4	17.2

Full term

N= 745,460

Table 4 shows an increase in the percent of births to foreign born Hispanic mothers, peaking at 11.6 percent in 2006. After 2006 the percentage of births foreign born Hispanic mothers rapidly declines. Meanwhile, there is steady growth in the percentage of births to U.S. born Hispanic mothers and steady and slow decline in the percentage of births to non-Hispanic white mothers. The results from Table 4 demonstrate that North Carolina may be a recent destination for Hispanic immigrants as it shows a large increase the percentage of births to foreign born Hispanic women. However, Hispanic immigration appears to be slowing in the late 2000s, possibly due to the economic recession.

Table 4: Maternal Race/Ethnicity and Year of Birth (%)

Birth Year	White	Black	US Hisp.	For. Hisp.
1990	71.3	27.1	0.7	1.0
1991	71.2	27.3	0.6	1.0
1992	70.9	27.0	0.7	1.4

1993	69.8	27.7	0.8	1.7
1994	70.2	26.8	0.9	2.1
1995	69.6	26.4	1.2	2.9
1996	69.8	25.1	1.2	4.0
1997	69.3	24.4	1.3	5.0
1998	69.0	24.1	1.3	5.6
1999	68.0	23.5	1.5	7.0
2000	66.9	22.6	1.5	8.9
2001	64.6	22.9	1.7	10.7
2002	65.1	22.6	1.8	10.5
2003	65.4	22.2	2.0	10.4
2004	64.7	22.7	2.0	10.6
2005	63.1	23.1	2.3	11.4
2006	62.4	23.5	2.5	11.6
2007	62.3	23.7	2.8	11.3
2008	62.5	24.5	3.2	9.8
2009	63.5	24.5	3.6	8.4
Total	66.8	24.5	1.7	6.9

N=901,873

Multinomial Logistic Regression Analysis

I use multinomial logistic regression to estimate the effects of race/ethnicity on birth weight. My use of a four category outcome variable improves on previous authors' use of binary logistic regression models by differentiating the magnitude of low birth weight and examining high birth weight. My model is robust to the independence of irrelevant alternatives assumption because the outcome variable is not based on choices, but rather the birth weight categories are constructed from interval-ratio level data. The model estimates the likelihood of a mother giving birth to a child with low, very low, or high birth weight relative to healthy birth weight in *i* births and *t* time.

$$ln\frac{p(Adverse\ BW = 3)_{it}}{p(Healthy\ BW = 1)_{it}} = \alpha + \beta_1 r_i + \beta_2 s_i + \beta_3 d_i + \beta_4 g_i + \beta_5 e_i + \beta_6 m_i + \beta_7 a_i + \beta_8 a_i^2 + \gamma_t = z$$

The hypothesized model includes terms for maternal race/ethnicity (*r*), prenatal smoking (*s*), gestational diabetes (*d*), and gestational age at birth (*g*). This model also includes control variables for maternal education (*e*), marriage at time of birth (*m*), maternal age (*a*), maternal age squared (a^2), and fixed effects for year of birth (γ). The outcome variable measures the log odds of adverse birth weight relative to that of healthy birth weight; it is represented by $ln\frac{p(Adverse\ BW=3)_{it}}{p(Healthy\ BW=1)_{it}}$. My outcome variable is displayed as relative risk ratios (RR). Significant results and non-significant results are shaded in grey and white respectively. Relative risk ratios from year fixed effects are not displayed with the results. I use a .001 alpha level as my large sample size causes my analysis to be very sensitive to significant results.

Model 1 in Table 5 is the bivariate model. Foreign born Hispanic mothers' first births have reduced risk (RR=.78, i.e, factor reduction in risk compared to non-Hispanic white mothers at 1.0) of very low and high (RR=.61) birth weight when compared with non-Hispanic white mothers ($p<.001$). Foreign born Hispanics are not significantly different from non-Hispanic whites in their risk of low birth weight. U.S. born Hispanics are not significantly different from non-Hispanic whites, except they have a lower risk of high birth weight. Non-Hispanic blacks have a greatly increased risk (RR= 2.81) of very low and low (RR=1.94) birth weight, but reduced risk (RR=.39) of high birth weight relative to non-Hispanic whites ($p<.001$).

When I add controls for maternal education, marriage at time of birth, and maternal age (see Model 2), the births of foreign born Hispanics gain an advantage in low birth weight in addition to their previous advantages in very low and high birth weight (when compared with the children of non-Hispanic white mothers). Net of other variables in the model, foreign born Hispanics have reduced risk of very low (RR=.66), low (RR=.76), and high (RR=.78) birth weight relative to non-Hispanic whites ($p<.001$). U.S. born Hispanics have similar risk of low and very low birth weight and decreased risk of high birth weight when compared to non-Hispanic whites. Non-Hispanic blacks continue to have increased risk of very low and low birth weight and decreased risk of high birth relative to non-Hispanic whites. Model 2 has an improved fit in comparison with Model 1.

Findings from Model 2 indicate that foreign born Hispanics' low levels of socioeconomic status are partially suppressing their low risk of adverse low birth weight.

Model 3 includes terms for the mediators, diabetes and prenatal smoking, in addition to control variables. Mothers who smoke during pregnancy are at increased risk of very low and low birth weight and decreased risk of high birth weight than non-smokers. Greater amounts of cigarettes smoked per day are consistently associated with increasing risk of low birth weight and decreasing risk of high birth weight.

Mothers with gestational diabetes have twice the risk of high (RR=2.01) birth weight relative to those without the condition when holding other variables in Model 3 constant ($p<.001$). However, in Model 3 foreign born Hispanics actually have a decreased risk of high birth weight in comparison with previous models. It is likely that foreign born Hispanics' low rates of prenatal smoking lead to increased risk of high birth weight. The influence of smoking on high birth weight appears to be more substantial than the influence of gestational diabetes, because of the large percentage of the population that smokes (relative to the small population that has gestational diabetes).

Adding variables for smoking and diabetes accounts for some of foreign born Hispanic mothers' advantage in very low and low birth weight (shown in Model 2). Simultaneously, the risk of very low and low birth weight increases for foreign born Hispanic mothers and decreases for non-Hispanic white mothers. Foreign born Hispanic mothers have a reduced risk of adverse birth weight compared to white mothers. The increased risk of very low (RR=.75) and low (RR=.92) birth weight among the children of foreign born Hispanic mothers in Model 3 relative to Model 2 (RR=.66 and RR=.76 respectively) indicate that smoking serves as a mediator for these outcomes. Foreign born Hispanics still have a reduced risk of very low (RR=.75), low (RR=.92), and high (RR=.67) birth weight relative to non-Hispanic white mothers when holding other variables constant ($p<.001$).

Non-Hispanic blacks and U.S. born Hispanics have increased risk of very low, low, and decreased risk of high birth weight relative to non-Hispanic whites in Model 3.

Model 4 includes another mediating variable (alongside the control variables), gestational age at birth, while excluding diabetes and prenatal smoking. Adding gestational age to the model greatly improves the fit; Model 4's BIC is nearly half of that of Model 2 and 3; it also reduces the odds of very low and low birth weight for each racial/ethnic group. While foreign born Hispanic mothers' advantage in low birth weight becomes smaller (relative to Model 2), they still have a reduced risk of very low (RR=.73), low (RR=.88), and high (RR=.74) birth weight relative to non-Hispanic white mothers when holding other factors constant ($p<.001$). However, their advantage in very low birth weight is negligible when gestational age is held at mean (week 39) as the predicted probability of having very low birth weight is almost zero for all fmy racial and ethnic groups in Model 4 (see Table 7 for predicted probabilities). This shift indicates that early term births likely account for most cases of very low birth weight.

Table 5: Multinomial Logit Model: Birth Weight Categories with Coefficients Displayed as Relative Risk Ratios

	Model 1			Model 2			Model 3			Model 4			Model 5		
	VLB	LBW	HBW	VLB	LBW	HBW	VLB	LBW	HBW	VLB	LBW	HBW	VLB	LBW	HBW
Race/Ethnicity															
Black	2.80	1.94	0.38	2.53	1.68	0.02	2.72	1.89	0.45	2.18	1.68	0.53	2.72	1.99	0.48
U.S. born Hispanic	1.18	1.11	0.65	1.18	1.04	0.77	1.25	1.15	0.72	0.93	1.04	0.78	1.12	1.20	0.72
Foreign born Hispanic	0.77	0.96	0.60	0.63	0.74	0.80	0.71	0.90	0.69	0.71	0.85	0.76	1.00	1.10	0.65
Maternal Education															
High School				0.85	0.79	1.34	0.89	0.85	1.24	0.80	0.79	1.34	0.91	0.87	1.24
Some College				0.73	0.66	1.37	0.79	0.75	1.20	0.58	0.63	1.37	0.73	0.74	1.21
Bachelor's				0.46	0.49	1.24	0.52	0.59	1.06	0.38	0.49	1.20	0.53	0.63	1.03
Married				1.32	1.27	0.78	1.27	1.18	0.85	1.27	1.30	0.76	1.12	1.18	0.83
Maternal Age				1.03	0.97	1.16	1.01	0.94	1.18	1.11	1.03	1.16	1.06	0.99	1.17
Maternal Age Squared				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Prenatal Smoking															
1 to 10 Cig.							1.45	1.73	0.45				2.70	2.04	0.44
10 to 20 Cig.							1.52	2.11	0.36				4.19	2.80	0.36
More than 20 Cig.							2.21	2.20	0.20				4.86	2.87	0.20
Gestational Diabetes							1.04	1.20	2.01				0.46	0.59	2.88
Gestational Age										0.17	0.41	1.78	0.17	0.40	1.81

p<=.001 (shaded)

	Model 1	Model 2	Model 3	Model 4	Model 5
df	69	87	99	90	99
LR chi2	10266	15451	18623	296268	300091
BIC	681390	676452	673445	395676	392018

N=901,873

U.S. born Hispanics have similar risk of low birth weight and decreased risk of high birth weight relative to non-Hispanic white mothers. As in previous models, non-Hispanic blacks have increased risk of low birth weight and decreased risk of high birth weight (when compared with non-Hispanic whites).

Model 5 is the hypothesized model; it includes diabetes, prenatal smoking, gestational age at birth, and control variables. Model 5 has the best fit of the five models with a BIC value slightly lower than that of Model 4. Like Model 4, the predicted probability (see Table 7) of very low birth weight in Model 5 is negligible for all racial/ethnic groups as the model holds gestational age at its mean (39 weeks). Foreign born Hispanics' reduced risk of low and very low birth weight (relative to non-Hispanic whites) disappears. In fact, foreign born Hispanic mothers have an increased risk of low birth weight (RR=1.13) relative to non-Hispanic white mothers net of other factors in Model 5 ($p<.001$). However, foreign born Hispanics' decreased risk of high birth weight (when compared with non-Hispanic whites) remains. While foreign born Hispanics have reduced risk of very low and low birth weight in comparison with non-Hispanic white mothers when including both low birth weight due to preterm birth and those caused by impeded intrauterine growth, they have increased risk of low birth weight when only examining births which are due to impeded intrauterine growth in comparison with non-Hispanic white mothers.

The effect of smoking increases in Model 5, indicating that gestational age is suppressing its influence. The risk of very low and low birth weight among mothers who smoke during the prenatal period greatly increases relative to that of non-smokers. Mothers who smoke 1-10 cigarettes each day have increased risk (RR=2.09) of low birth weight relative to non-smokers when holding other variables constant ($p<.001$). Akin to Model 3, the risk of low birth weight increases and the risk of high birth weight decreases with the amount of cigarettes smoked each day. This finding indicates that prenatal smoking has a more substantial effect on impeding intrauterine growth than on inducing preterm birth.

Consistent with my conceptual model (see Figure 1), foreign born Hispanic mothers' low rates of prenatal smoking and longer pregnancies serve as mechanisms for foreign born Hispanic mothers' reduced risk of very low and low birth weight vis-à-vis non-Hispanic white mothers.

Effects of Hispanic Ethnicity on Gestational Age: Conditional Cox Proportional Hazard Model

Motived by the finding that foreign born Hispanic mothers' reduced risk of low birth weight is partially mediated by gestational age, I use a second model to decompose the effects of Hispanic ethnicity on gestational age at birth.

I use a Cox Proportional Hazards model in order to examine potential mechanisms for foreign born Hispanic mothers' longer gestational periods. This model is conditional on survival at birth, as fetal deaths are not included in these data. I also exclude births with gestational ages lower than 30 weeks and those (greater than 30 weeks) with birth weight lower than 1,500 grams due to high risk of fetal death for births of these categories. Past research finds that the average birth weight at 30 weeks is 1,500 grams (Kramer et al. 2001) and small for gestational age births are at greatly increased risk of fetal death (Cnattingius et al. 1998), I can assume that most removing very low birth weight and very early births will exclude births at highest risk of fetal mortality. This exclusion removes potential bias from fetal death from my models. Similar research on prenatal and neonatal health utilizes Cox Proportional Hazards models in order to analyze variations in time to event (Hartnoll et al. 2000; Bartels et al. 2005). Because the Cox regression model is semi-parametric, it does not require that a distribution be specified. The use of a partial likelihood estimator allows for coefficients to be estimated without a baseline hazard function. Cox regression models estimate the instantaneous hazard of an event occurring using hazard ratios (Allison 2012). In my model, the event occurring is birth. The Cox Proportional Hazards model operates under the proportional odds assumption, assuming that the hazard ratios of variables in the model do not change over time. While there may be interactions between variables in the Cox regression model and time (gestational age), the model estimates the averages of the variables, providing a useful approximation of the association between race/ethnicity and gestational age at birth.

Analysis

My conditional hazards model estimates the hazard of birth in *i* births and *t* time during the gestational period (*g*) such that:

$$Hazard\ of\ Birth(g)_{it} = h_0(g)\exp(\beta_1 r_i + \beta_2 s_i + \beta_3 d_i + \beta_4 e_i + \beta_5 m_i + \beta_6 a_i + \beta_7 a_i^2 + \gamma_t)$$

Where *r* serves as a term for maternal race/ethnicity, *s* represents a term for prenatal smoking, and *d* serves as a term for gestational diabetes. The model also includes control variables for maternal education (*e*), marriage at time of birth (*m*), age (*a*), and age squared (a^2), and fixed effects for year of birth (γ). The unobserved baseline hazard is represented by $h_0(g)$. All results are displayed as hazard ratios, with significant results shaded in grey. Hazard ratios for year of birth are not displayed in Table 6. Similar to my first model, I use a .001 alpha level for measuring significance because of my large sample size.

All results are displayed as hazard ratios, with significant results shaded in grey. Hazard ratios for year of birth are not displayed in Table 6. Similar to my first model, I use a .001 alpha level for measuring significance because of my large sample size.

Model 1 is the bivariate model, measuring "survival" in gestation by race/ethnicity. Foreign born Hispanic mothers have lower risk of birth at each week than those of non-Hispanic white mothers (Model 1). The hazard of birth for foreign born Hispanic mothers is 6 percent lower than that of non-Hispanic white mothers ($p<.001$). Non-Hispanic black mothers have an 11 percent higher hazard of birth in comparison with the children of non-Hispanic white mothers net of other variables in the model (p<.001). There is no significance difference between the risk of birth for U.S. born Hispanic mothers and non-Hispanic white mothers.

Table 6: Cox Proportional Hazard Model: Gestational Age at Birth

	Model 1		Model 2		Model 3	
	HR	SE	HR	SE	HR	SE
Race/Ethnicity						
Black	1.091	0.003	1.097	0.003	1.102	0.003
U.S. born Hispanic	1.009	0.008	1.012	0.008	1.016	0.008
Foreign born Hispanic	0.942	0.004	0.939	0.004	0.948	0.004
Maternal Education						
HS completion			0.984	0.003	0.989	0.003
Some College			0.985	0.004	0.993	0.004
Bachelor's degree			0.945	0.004	0.961	0.005
Married			0.990	0.003	0.987	0.003
Maternal Age			0.985	0.002	0.982	0.002
Maternal Age Squared			1.000	0.000	1.000	0.000
Prenatal Smoking						
1 to 10 Cig.					1.032	0.004
10 to 20 Cig.					1.049	0.007
More than 20 Cig.					1.056	0.021
Gestational Diabetes					1.451	0.010

p<=.001 (shaded)

	Model 1	Model 2	Model 3
df	22	28	32
LR chi2	8422	9107	11791

N=886,954

Model 2 includes control variables for maternal education and maternal age. Consistent with findings from Model 1, non-Hispanic black mothers have an 11 percent higher hazard of birth in comparison with the children of non-Hispanic white mothers net of other variables in the model (p<.001). Likewise, there is no significant difference in the hazard of birth for U.S. born Hispanic mothers and non-Hispanic white mothers. While controlling for maternal education and maternal age at birth improves model fit,[8] it has no impact on foreign born Hispanic mothers' increased gestational age vis-à-vis non-Hispanic white mothers.

Model 3 includes mediating terms for prenatal smoking and gestational diabetes. Adding terms for prenatal smoking and diabetes does not impact foreign born Hispanic mothers' tendency towards longer pregnancies. The hazard of birth for the children of foreign born Hispanic mothers is 6 percent lower than that of the children of white mothers when holding all other terms in the model constant ($p<.001$). Consistent with previous models, non-Hispanic black mothers have earlier births than white mothers and U.S. born Hispanic mothers have similar length of pregnancy in comparison with non-Hispanic white mothers.

In comparison with non-smokers, mothers who smoke during pregnancy have shorter pregnancies. The risk of early birth increases with the amount of cigarettes smoked daily with 4, 5, and 7 percent increases (for those who smoke 1-10, 11-20, and 20 or more cigarettes per day respectively) in the hazard of birth relative to non-smokers. Likewise, mothers with diabetes have a 45 percent greater hazard of birth relative to mothers without diabetes net of other variables in the model ($p<.001$). Model 3 has the greatest statistical fit of the three models.

The Cox regression analysis[9] shows that foreign born Hispanic mothers have longer pregnancies than non-Hispanic white mothers. While prenatal smoking and gestational diabetes are associated with decreased gestational age at birth, foreign born Hispanic mothers' longer pregnancies (relative to those of non-Hispanic white mothers) are not fully explained by their lower rates of prenatal smoking or gestational diabetes.

---

[8] BIC was not used to measure goodness of fit as the large sample size made the fit statistics for the three models indistinguishable.

[9] I ran supplemental analyses using OLS, binary logit (preterm/non-preterm), and multinomial logit (four categories of gestational age) models. Like the Cox Proportional Hazards model, these analyses found that foreign born Hispanics have a robust advantage in pregnancy length relative to non-Hispanic whites. The multinomial logit model found their favorable birth profile to be consistent throughout gestation, providing evidence for the proportional hazards assumption.

Discussion

Mechanisms for the Birth Weight Paradox

Using the North Carolina birth certificates, I find that foreign born Hispanic mothers have considerably lower risk of adverse birth weight than white mothers. While foreign born Hispanic mothers have slightly favorable birth weight outcomes in the bivariate model, their advantage over non-Hispanic white mothers becomes more substantial when I account for socioeconomic status and maternal age. Moreover, foreign born Hispanic mothers' reduced risk of low birth weight is mediated by longer pregnancies and lower rates of prenatal smoking vis-à-vis non-Hispanic white mothers, overwhelming the negative effects of low socioeconomic status. These findings are consistent with my conceptual model (see Figure 1).

Interestingly, the relationship between prenatal smoking and low birth weight is partially suppressed by, rather than mediating through, gestational age, diverging from my conceptual model. This suppression indicates that smoking has a stronger effect on impeding intrauterine growth than on inducing early pregnancy. While foreign born Hispanics are not a homogenous group, they are homogenous in prenatal smoking behavior (over 99% are nonsmokers). This population propensity benefits these mothers in having relatively low rates of low birth weight.

U.S. born Hispanic mothers do not share the positive birth weight profile of foreign born Hispanics; their birth weight profile resembles that of non-Hispanic whites. U.S. born Hispanics acquire many of the same negative health behaviors as non-Hispanic white and non-Hispanic blacks, such as smoking and poor diet, negatively influencing their birth weight profile.

High Birth Weight

While past research on birth weight usually concentrates on low birth weight, high birth weight has been left relatively unexamined. Notably, non-Hispanic white mothers are at increased risk of unhealthy high birth weight in comparison to foreign born Hispanic, U.S. born Hispanic, and non-Hispanic black mothers.

Non-Hispanic white mothers' elevated risk of high birth weight could be explained by racial/ethnic differences in height and obesity (Ørskou et al. 2003; Shrutz et al. 2012). If a child's appropriate birth weight is relative to parental height, these births may not be of an unhealthy weight. However, the use of a relatively high bar for high birth weight (4,500 grams) in lieu of a lower bar (4,000 grams), should account for much of the variability due to parental height. It is much more likely that high birth weight in my data are due to maternal obesity rather than height.

Updating Past Findings

My research finds more notable advantage for foreign born Hispanics in avoiding low birth weight (vis-à-vis non-Hispanic whites) than previous literature on the birth weight "Paradox" (Acevedo-Garcia et al. 2007; Leslie et al. 2003; Hessol and Fuentes-Afflick 2000; Fuentes-Afflick et al. 1999; Fuentes-Afflick and Lurie 1997). Prior research finds that Hispanics have similar or even slightly increased rates of low birth weight relative to non-Hispanic whites; in contrast, by using iterative analysis my research finds reduced rates of very low, low, and high birth weight for foreign born Hispanics in comparison with non-Hispanic whites.[10] Consistent with recent research on Hispanic Paradox and mortality (Lariscy et al. 2015), I find that low socioeconomic status partially suppresses foreign born Hispanics' healthy birth weight profile.

Foreign born Hispanics' healthy birth weight profile relative to that of U.S. born Hispanics lends support to the healthy immigrant selectivity hypothesis. My analysis, however, only partially resolves the "Paradox." Prenatal smoking accounts for a portion of foreign born Hispanic mothers'

[10] Supplemental analysis finds no difference in the relationship between race/ethnicity and birth weight for the two decades of analysis (1990-2009). This analysis is available in an appendix on request from the authors.

relatively low rates of low birth weight. However, the analysis does not explain foreign born Hispanic mothers' longer pregnancies. My only option is to speculate on possible mechanisms.

If foreign born Hispanic mothers are selected on better health, they may have decreased chance of preterm birth vis-à-vis the average mother from the immigrants' native country (and non-Hispanic whites in the U.S.). Yet, the healthy immigrant hypothesis does not provide a plausible mechanism. While cultural buffering through community support is possible, it is unlikely to be a key factor in pregnancy length.[11] Possibly, these women have healthier diets than non-Hispanic white mothers and Hispanic mothers born in the U.S.[12] As previously mentioned, diet among Hispanics becomes less healthy in subsequent generations of Hispanic Americans following immigration to the U.S. (Guendelman and Adams 1995). The diet hypothesis is consistent with the finding that U.S. born Hispanic mothers have increased risk of low birth weight relative to foreign born Hispanic mothers.

Conclusion

My analysis finds a Hispanic Paradox in North Carolina. Foreign born Hispanic mothers have reduced risk of giving birth to children with low, very low, and high birth weight vis-à-vis non-Hispanic white mothers. The foreign born Hispanic advantage in low birth weight is explained by low rates of prenatal smoking and longer pregnancies. The subsequent analysis was unable to determine a mechanism for foreign born Hispanic mothers' relatively long pregnancies.

My adoption of a more refined measure of birth weight allows for the examination of high birth weight in the context of the Hispanic birth weight Paradox. Foreign born Hispanic mothers (as well as Black and U.S. born Hispanic mothers) have reduced risk of high birth weight relative to

---

[11] Research on preterm birth, social support, and stress has inconsistent findings. If anything, there is little support that social support is associated with lower risk of preterm birth (Dole et al. 2003; Copper et al. 1996).

[12] Healthy diet has been linked to reduced risk of preterm birth (Scholl et al. 1992; Siega-Riz et al. 2004; Mikkelson et al. 2008).

non-Hispanic white mothers. While gestational diabetes is associated with an increased risk of high birth weight, it is not an influential mechanism. Maternal obesity and height may account for non-Hispanic white mothers' relatively high rates of heavy births.

This research serves as an update on previous research on the Hispanic birth weight Paradox. My findings indicate that Hispanics have a more clear advantage in birth weight than in past research (Acevedo-Garcia et al. 2007; Leslie et al. 2003; Hesson and Fuentes-Afflick 2000; Fuentes-Afflick et al. 1999; Fuentes-Afflick and Lurie 1997). Future research on the birth weight "Paradox" may wish to examine shifting trends in birth weight by racial and ethnic groups and the population level influence of nutrition on birth weight.

APPENDIX

Using the parameter estimates derived from my first model, I calculated the predicted probabilities of falling into a birth weight category (see Table 7). These predicted probabilities are calculated with each independent variable held at its mean using this equation:

$$p(BW\ Category) = \frac{\exp(z_{BW\ Category})}{1 + \sum \exp(z_{BW\ Category})}$$

Predicted probabilities from maternal education, maternal age, maternal age squared, and fixed effects for each year of birth are not displayed with the results.

Table 7: Multinomial Logit Model: Birth Weight Categories using Predicted Probabilities

	Model 1				Model 2				Model 3			
	VLBW	LBW	Normal	HBW	VLBW	LBW	Normal	HBW	VLBW	LBW	Normal	HBW
White	0.012	0.054	0.920	0.014	0.011	0.055	0.921	0.013	0.011	0.052	0.924	0.013
Black	0.031	0.099	0.865	0.005	0.030	0.095	0.869	0.005	0.031	0.098	0.866	0.005
U.S. Born Hisp.	0.014	0.060	0.917	0.009	0.014	0.057	0.919	0.010	0.014	0.060	0.917	0.009
For. Born Hisp.	0.009	0.052	0.930	0.009	0.008	0.042	0.940	0.010	0.008	0.048	0.935	0.009
Non-smoker									0.014	0.057	0.919	0.011
1-10 Cig.									0.020	0.097	0.879	0.005
11-20 Cig.									0.020	0.116	0.861	0.004
More than 20									0.029	0.119	0.850	0.002
No Diabetes									0.014	0.061	0.916	0.010
Diabetes									0.015	0.071	0.895	0.019

	Model 4				Model 5			
	VLBW	LBW	Normal	HBW	VLBW	LBW	Normal	HBW
White	0.000	0.022	0.969	0.008	0.000	0.021	0.972	0.008
Black	0.000	0.041	0.955	0.004	0.000	0.043	0.954	0.003
U.S. Born Hisp.	0.000	0.024	0.970	0.006	0.000	0.025	0.969	0.006
For. Born Hisp.	0.000	0.020	0.974	0.006	0.000	0.023	0.972	0.005
Non-smoker					0.000	0.023	0.970	0.007
1-10 Cig.					0.000	0.047	0.950	0.003
11-20 Cig.					0.000	0.063	0.935	0.002
More than 20					0.000	0.064	0.935	0.001
No Diabetes					0.000	0.025	0.969	0.006
Diabetes					0.000	0.015	0.968	0.017
Gest. Age (Weeks)								
24	0.996	0.004	0.000	0.000	0.996	0.004	0.000	0.000
28	0.890	0.109	0.000	0.000	0.890	0.109	0.000	0.000
32	0.191	0.752	0.057	0.000	0.190	0.754	0.056	0.000
36	0.002	0.261	0.736	0.001	0.002	0.259	0.738	0.001
40	0.000	0.009	0.978	0.013	0.000	0.009	0.979	0.012
44	0.000	0.000	0.888	0.112	0.000	0.000	0.886	0.114

REFERENCES

Abel, Ernest L, Michael Kruger and Larry Burd. 2002. "Effects of Maternal and Paternal Age on Caucasian and Native American Preterm Births and Birth Weights." *American Journal of Perinatology* 19(1):49-54.

Acevedo-Garcia, Dolores, Mah-J Soobader and Lisa F Berkman. 2005. "The Differential Effect of Foreign-Born Status on Low Birth Weight by Race/Ethnicity and Education." *Pediatrics* 115(1):e20-e30.

Acevedo-Garcia, Dolores, Mah-J Soobader and Lisa F Berkman. 2007. "Low Birthweight among Us Hispanic/Latino Subgroups: The Effect of Maternal Foreign-Born Status and Education." *Social Science & Medicine* 65(12):2503-16.

Allison, Paul D. 2010. *Survival Analysis Using SAS: A Practical Guide*. Cary, NC: SAS Institute.

Berard, J, P Dufmy, D Vinatier, D Subtil, S Vanderstichele, JC Monnier and F Puech. 1998. "Fetal Macrosomia: Risk Factors and Outcome: A Study of the Outcome Concerning 100 Cases> 4500 G." *European Journal of Obstetrics & Gynecology and Reproductive Biology* 77(1):51-59.

Berkowitz, Gertrud S and Emile Papiernik. 1993. "Epidemiology of Preterm Birth." *Epidemiologic Reviews* 15(2):414-43.

Boulet, Sheree L, Greg R Alexander, Hamisu M Salihu and MaryAnn Pass. 2003. "Macrosomic Births in the United States: Determinants, Outcomes, and Proposed Grades of Risk." *American Journal of obstetrics and gynecology* 188(5):1372-78.

Breborowicz, GH. 2001. "Limits of fetal viability and its enhancement." *Early Pregnancy (Online)* 5:49-50.

Brooke, Oliver G, H Ross Anderson, J Martin Bland, Janet L Peacock and C Malcolm Stewart. 1989. "Effects on Birth Weight of Smoking, Alcohol, Caffeine, Socioeconomic Factors, and Psychosocial Stress." *Bmj* 298(6676):795-801.

Buekens, Pierre, Francis Notzon, Milton Kotelchuck and Allen Wilcox. 2000. "Why Do Mexican Americans Give Birth to Few Low-Birth-Weight Infants?". *American Journal of Epidemiology* 152(4):347-51.

Child Trends. 2015. “Low and Very Low Birthweight Infants.” Child Trends. Washington, D.C.

Chomitz, Virginia Rall, Lilian WY Cheung and Ellice Lieberman. 1995. "The Role of Lifestyle in Preventing Low Birth Weight." *The Future of Children*: 121-38.

Cnattingius, Sven, Michele R Forman, Heinz W Berendes, Barry I. Graubard and Leena Isotalo. 1993. "Effect of Age, Parity, and Smoking on Pregnancy Outcome: A Population-Based Study." *American Journal of Obstetrics and Gynecology* 168(1):16-21.

Cnattingius, Sven, Michele R Forman, Heinz W Berendes, Barry I Graubard and Leena Isotalo. 1993. "Effect of Age, Parity, and Smoking on Pregnancy Outcome: A Population-Based Study." *American Journal of Obstetrics and Gynecology* 168(1):16-21.

Cobas, Jose A, Hector Balcazar, Mary B Benin, Verna M Keith and Yinong Chong. 1996. "Acculturation and Low-Birthweight Infants among Latino Women: A Reanalysis of Hhanes Data with Structural Equation Models." *American Journal of Public Health* 86(3):394-96.

Copper, Rachel L, Robert L Goldenberg, Anita Das, Nancy Elder, Melissa Swain, Gwendolyn Norman, Risa Ramsey, Peggy Cotroneo, Beth A Collins and Francee Johnson. 1996. "The Preterm Prediction Study: Maternal Stress Is Associated with Spontaneous Preterm Birth at Less Than Thirty-Five Weeks' Gestation." *American Journal of Obstetrics and Gynecology* 175(5):1286-92.

Crimmins, Eileen M, Jung Ki Kim, Dawn E Alley, Arun Karlamangla and Teresa Seeman. 2007. "Hispanic Paradox in Biological Risk Profiles." *American Journal of Public Health* 97(7):1305-10.

Croen, Lisa A and Gary M Shaw. 1995. "Young Maternal Age and Congenital Malformations: A Population-Based Study." *American Journal of Public Health* 85(5):710-13.

Curhan, Gary C, Walter C Willett, Eric B Rimm, Donna Spiegelman, Alberto L Ascherio and Meir J Stampfer. 1996. "Birth Weight and Adult Hypertension, Diabetes Mellitus, and Obesity in Us Men." *Circulation* 94(12):3246-50.

Davidoff, Michael J, Todd Dias, Karla Damus, Rebecca Russell, Vani R Bettegowda, Siobhan Dolan, Richard H Schwarz, Nancy S Green and Joann Petrini. 2006. "Changes in the Gestational Age Distribution among Us Singleton Births: Impact on Rates of Late Preterm Birth, 1992 to 2002." Pp. 8-15 in *Seminars in Perinatology*, Vol. 30: Elsevier.

Deckelbaum, Richard J and Christine L Williams. 2001. "Childhood Obesity: The Health Issue." *Obesity Research* 9(S11):239S-43S.

Dole, Nancy, David A Savitz, Irva Hertz-Picciotto, Anna Maria Siega-Riz, Michael J McMahon and Pierre Buekens. 2003. "Maternal Stress and Preterm Birth." *American Journal of Epidemiology* 157(1):14-24.

Dunson, David B, Bernardo Colombo and Donna D Baird. 2002. "Changes with Age in the Level and Duration of Fertility in the Menstrual Cycle." *Human Reproduction* 17(5):1399-403.

Durand, Jorge, Douglas S Massey and Fernando Charvet. 2000. "The Changing Geography of Mexican Immigration to the United States: 1910-1996." *Social Science Quarterly*:1-15.

Durand, Jorge, Douglas S Massey and Rene M Zenteno. 2001. "Mexican Immigration to the United States: Continuities and Changes." *Latin American Research Review*:107-27.

Durand, Jorge, Douglas S Massey and Chiara Capoferro. 2005. "The New Geography of Mexican Immigration." *New Destinations: Mexican Immigration in the United States*:1-20.

Frank, Reanne and Robert A Hummer. 2002. "The Other Side of the Paradox: The Risk of Low Birth Weight among Infants of Migrant and Nonmigrant Households within Mexico." *International Migration Review* 36(3):746-65.

Frisbie, W. Parker. 2005. "Infant Mortality." Chapter 9 (pp. 251-283) in *Handbook of Population*, edited by Dudley L. Poston and Michael Micklin. NY: Springer.

Fuentes-Afflick, Elena and P. Lurie. 1997. "Low Birth Weight and Latino Ethnicity: Examining the Epidemiologic Paradox." *Archives of Pediatrics & Adolescent Medicine* 151(7):665-74.

Fuentes-Afflick, Elena, Nancy A Hessol and Eliseo J Pérez-Stable. 1998. "Maternal Birthplace, Ethnicity, and Low Birth Weight in California." *Archives of Pediatrics & Adolescent Medicine* 152(11):1105-12.

Fuentes-Afflick, Elena, Nancy A Hessol and Eliseo J Pérez-Stable. 1999. "Testing the Epidemiologic Paradox of Low Birth Weight in Latinos." *Archives of Pediatrics & Adolescent Medicine* 153(2):147-53.

Gillman, Matthew W, Sheryl Rifas-Shiman, Catherine S Berkey, Alison E Field and Graham A Colditz. 2003. "Maternal Gestational Diabetes, Birth Weight, and Adolescent Obesity." *Pediatrics* 111(3):e221-e26.

Goldenberg, Robert L, Jennifer F Culhane, Jay D Iams and Roberto Romero. 2008. "Epidemiology and Causes of Preterm Birth." *The Lancet* 371(9606):75-84.

Guendelman, Sylvia and Barbara Abrams. 1995. "Dietary Intake among Mexican-American Women: Generational Differences and a Comparison with White Non-Hispanic Women." *American Journal of Public Health* 85(1):20-25.

Hedderson, Monique M, Assiamira Ferrara and David A Sacks. 2003. "Gestational Diabetes Mellitus and Lesser Degrees of Pregnancy Hyperglycemia: Association with Increased Risk of Spontaneous Preterm Birth." *Obstetrics & Gynecology* 102(4):850-56.

Hummer, Robert A, Daniel A Powers, Starling G Pullum, Ginger L Gossman and W Parker Frisbie. 2007. "Paradox Found (Again): Infant Mortality among the Mexican-Origin Population in the United States." *Demography* 44(3):441-57.

Hunt, Kelly J, Roy G Resendez, Ken Williams, Steve M Haffner, Michael P Stern and Helen P Hazuda. 2003. "All-Cause and Cardiovascular Mortality among Mexican-American and Non-Hispanic White Older Participants in the San Antonio Heart Study—Evidence against the "Hispanic Paradox"." *American Journal of Epidemiology* 158(11):1048-57.

Joseph, K S, Alexander C Allen, Linda Dodds, Linda Ann Turner, Heather Scott and Robert Liston. 2005. "The Perinatal Effects of Delayed Childbearing." *Obstetrics & Gynecology* 105(6):1410-18.

Kandel, William A and Emilio A Parrado. 2006. "Hispanic Population Growth and Public School Response in Two New South Immigrant Destinations." *Latinos in the New South: Transformations of Place*:111-34.

Kleinman, Joel C and Samuel S Kessel. 1987b. "Racial Differences in Low Birth Weight. Trends and Risk Factors." *The New England Journal of Medicine* 317(12):749-53.

Kramer, Michael S. 1987. "Determinants of Low Birth Weight: Methodological Assessment and Meta-Analysis." *Bulletin of the World Health Organization* 65(5):663.

Kramer, Michael S, Robert W Platt, Shi Wu Wen, KS Joseph, Alexander Allen, Michal Abrahamowicz, Béatrice Blondel and Gérard Bréart. 2001a. "A New and Improved Population-Based Canadian Reference for Birth Weight for Gestational Age." *Pediatrics* 108(2):e35-e35.

Lariscy, Joseph T, Robert A Hummer and Mark D Hayward. 2015. "Hispanic Older Adult Mortality in the United States: New Estimates and an Assessment of Factors Shaping the Hispanic Paradox." *Demography* 52(1):1-14.

Lauderdale, Diane S. 2006. "Birth Outcomes for Arabic-Named Women in California before and after September 11." *Demography* 43(1):185-201.

Lee, Kwang-sun, Richard M Ferguson, Maria Corpuz and Lawrence M Gartner. 1988. "Maternal Age and Incidence of Low Birth Weight at Term: A Population Study." *American Journal of Obstetrics and Gynecology* 158(1):84-89.

Leslie, Jennie C, Shelley L Galvin, Sandra J Diehl, Trude A Bennett and Paul A Buescher. 2003. "Infant Mortality, Low Birth Weight, and Prematurity among Hispanic, White, and African American Women in North Carolina." *American Jmynal of Obstetrics and Gynecology* 188(5):1238-40.

Lewit, Eugene M, Linda Schuurmann Baker, Hope Corman and Patricia H Shiono. 1995. "The Direct Cost of Low Birth Weight." *The Future of Children*: 35-56.

Lipscomb, Kim R, Kimberly Gregory and Kathryn Shaw. 1995. "The Outcome of Macrosomic Infants Weighing at Least 4500 Grams: Los Angeles County+ University of Southern California Experience." *Obstetrics & Gynecology* 85(4):558-64.

Luo, Zhong-Cheng, Russell Wilkins and Michael S Kramer. 2006. "Effect of Neighbmyhood Income and Maternal Education on Birth Outcomes: A Population-Based Study." *Canadian Medical Association Journal* 174(10):1415-20.

Markides, Kyriakos S and Jeannine Coreil. 1986a. "The Health of Hispanics in the Southwestern United States: An Epidemiologic Paradox." *Public Health Reports* 101(3):253.

Markides, Kyriakos S and Karl Eschbach. 2005. "Aging, Migration, and Mortality: Current Status of Research on the Hispanic Paradox." *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences* 60(Special Issue 2):S68-S75.

Markides, Kyriakos S and Karl Eschbach. 2011. "Hispanic Paradox in Adult Mortality in the United States." Pp. 227-40 in *International Handbook of Adult Mortality*: Springer.

Martin, Joyce A, Brady E Hamilton, Michelle J.K Osterman, Sally C Curtin, T.J Matthews. 2013. "Births: Final Data for 2013." *National Vital Statistics Reports* 64(1).

Mikkelsen, Tina B, Marie Louise østerdal, Vibeke K Knudsen, Margaretha Haugen, Helle M Meltzer, Leiv Bakketeig and Sjurdur F Olsen. 2008. "Association between a Mediterranean-Type Diet and Risk of Preterm Birth among Danish Women: A Prospective Cohort Study." *Acta Obstetricia et Gynecologica Scandinavica* 87(3):325-30.

Misra, Dawn P and Cande V Ananth. 2002. "Infant Mortality among Singletons and Twins in the United States During 2 Decades: Effects of Maternal Age." *Pediatrics* 110(6):1163-68.

Myrskylä, Mikko, Karri Silventoinen, Per Tynelius and Finn Rasmussen. 2013. "Is Later Better or Worse? Association of Advanced Parental Age with Offspring Cognitive Ability among Half a Million Young Swedish Men." *American Journal of Epidemiology*: kws237.

Nassar, Anwar H, Ihab M Usta, Ali M Khalil, Ziad I Melhem, Toufic I Nakad and Antoine A Abu Musa. 2003. "Fetal Macrosomia (≥ 4500 G): Perinatal Outcome of 231 Cases According to the Mode of Delivery." *Journal of Perinatology* 23(2):136-41.

Naver, Klara Vinsand, Niels Jørgen Secher, Per Glud Ovesen, Anders Gorst-Rasmussen, Søren Lundbye-Christensen and Lisbeth Nilas. 2013. "Offspring Preterm Birth and Birth Size Are Related to Long-Term Risk of Maternal Diabetes." *European Journal of Epidemiology* 28(5):427-32.

North Carolina Center for Vital Statistics. 2014. 1990-2009 North Carolina Birth Certificate Data Set and Documentation. NCCVS CD-ROM (unknown), issued August 2014. Raleigh, NC: North Carolina Department of Health and Human Services.

Palloni, Alberto and Elizabeth Arias. 2004. "Paradox Lost: Explaining the Hispanic Adult Mortality Advantage." *Demography* 41(3):385-415.

Parrado, Emilio A. 2011. "How High Is Hispanic/Mexican Fertility in the United States? Immigration and Tempo Considerations." *Demography* 48(3):1059-80.

Pew Forum. 2011. *Demographic Profile of Hispanics in North Carolina, 2011*. Washington, DC: U.S.

Powers, Daniel A. 2013. "Paradox Revisited: A Further Investigation of Racial/Ethnic Differences in Infant Mortality by Maternal Age." *Demography* 50(2):495-520.

Russell, Rebecca B, Nancy S Green, Claudia A Steiner, Susan Meikle, Jennifer L Howse, Karalee Poschman, Todd Dias, Lisa Potetz, Michael J Davidoff and Karla Damus. 2007. "Cost of Hospitalization for Preterm and Low Birth Weight Infants in the United States." *Pediatrics* 120(1):e1-e9.

Savitz, David A, James W Terry, Nancy Dole, John M Thorp, Anna Maria Siega-Riz and Amy H Herring. 2002. "Comparison of Pregnancy Dating by Last Menstrual Period, Ultrasound Scanning, and Their Combination." *American Journal of Obstetrics and Gynecology* 187(6):1660-66.

Savitz, David A, Quaker Harmon, Anna Maria Siega-Riz, Amy H Herring, Nancy Dole and John M Thorp Jr. 2012. "Behavioral Influences on Preterm Birth: Integrated Analysis of the Pregnancy, Infection, and Nutrition Study." *Maternal and Child Health Journal* 16(6):1151-63.

Schieve, Laura A, Susan F Meikle, Cynthia Ferre, Herbert B Peterson, Gary Jeng and Lynne S Wilcox. 2002b. "Low and Very Low Birth Weight in Infants Conceived with Use of Assisted Reproductive Technology." *New England Journal of Medicine* 346(10):731-37.

Scholl, Theresa O, Mary L Hediger, Richard L Fischer and Joanne W Shearer. 1992. "Anemia Vs Iron Deficiency: Increased Risk of Preterm Delivery in a Prospective Study." *The American Journal of Clinical Nutrition* 55(5):985-88.

Siega-Riz, Anna Maria, David A Savitz, Steven H Zeisel, John M Thorp and Amy Herring. 2004. "Second Trimester Folate Status and Preterm Birth." *American Journal of Obstetrics and Gynecology* 191(6):1851-57.

Shiono, Patricia H and Richard E Behrman. 1995. "Low Birth Weight: Analysis and Recommendations." *The Future of Children*:4-18.

Smith, David P and Benjamin S Bradshaw. 2006. "Rethinking the Hispanic Paradox: Death Rates and Life Expectancy for Us Non-Hispanic White and Hispanic Populations." *American Journal of Public Health* 96(9):1686-92.

Stein, Zena and Mervyn Susser. 2000. "The Risks of Having Children in Later Life: Social Advantage

May Make up for Biological Disadvantage." *BMJ: British Medical Journal* 320(7251):1681.

Stotland, Naomi E, Linda M Hopkins and Aaron B Caughey. 2004. "Gestational Weight Gain, Macrosomia, and Risk of Cesarean Birth in Nondiabetic Nulliparas." *Obstetrics & Gynecology* 104(4):671-77.

Stotland, NE, AB Caughey, EM Breed and GJ Escobar. 2004. "Risk Factors and Obstetric Complications Associated with Macrosomia." *International Journal of Gynecology & Obstetrics* 87(3):220-26.

Strutz, Kelly L, Liana J. Richardson and Jon M Hussey. 2012. "Preconception Health Trajectories and Birth Weight in a National Prospective Cohort." *Journal of Adolescent Health* 51(6):629-36.

Turra, Cassio M. and Noreen Goldman. 2007. "Socioeconomic Differences in Mortality among U.S. Adults: Insights into the Hispanic Paradox." *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences* 62(3):S184-S92.

Tye, Joe B, Kenneth E Warner and Stanton A Glantz. 1987. "Tobacco Advertising and Consumption: Evidence of a Causal Relationship." *Journal of Public Health Policy*:492-508.

Victoria, Cesar G, Sharon RA Huttly, Fernando C Barros, Cintia Lombardi and J Patrick Vaughan. 1992. "Maternal Education in Relation to Early and Late Child Health Outcomes: Findings from a Brazilian Cohort Study." *Social Science & Medicine* 34(8):899-905.

Vinikoor, Lisa C, Lynne C Messer, Barbara A Laraia and Jay S Kaufman. 2010. "Reliability of Variables on the North Carolina Birth Certificate: A Comparison with Directly Queried Values from a Cohort Study." *Paediatric and Perinatal Epidemiology* 24(1):102-12.

Wei, Jung-Nan, Fung-Chang Sung, Chung-Yi Li, Chia-Hsuin Chang, Ruey-Shiung Lin, Chau-Ching Lin, Chuan-Chi Chiang and Lee-Ming Chuang. 2003. "Low Birth Weight and High Birth Weight Infants Are Both at an Increased Risk to Have Type 2 Diabetes among Schoolchildren in Taiwan." *Diabetes Care* 26(2):343-48.

Xiong, X, LD Saunders, FL Wang and NN Demianczuk. 2001. "Gestational Diabetes Mellitus: Prevalence, Risk Factors, Maternal and Infant Outcomes." *International Journal of Gynecology & Obstetrics* 75(3):221-28.

Ørskou, Janne, Tine Brink Henriksen, Ulrik Kesmodel and Niels Jørgen Secher. 2003a. "Maternal

Characteristics and Lifestyle Factors and the Risk of Delivering High Birth Weight Infants."
Obstetrics & Gynecology 102(1):115-20.