DISSERTATION

A Good Start in Life

Revisiting Racial and Ethnic Disparities in Health Outcomes At and After Birth

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This document was submitted as a dissertation in March 2007 in partial fulfillment of the requirements of the doctoral degree in public policy analysis at the Pardee RAND Graduate School. The faculty committee that supervised and approved the dissertation consisted of Brian K. Finch (Chair), M. Rebecca Kilburn, and Julie DaVanzo.

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Abstract

Intergroup differences in health can reflect on and result in unequal life opportunities. In particular, racial and ethnic disparities in birth outcomes have long been a concern for both researchers and policy makers. Differences in health at birth are especially critical because they may lead to disparities in health as well as socioeconomic conditions throughout one's whole life.

This dissertation contributes to three aspects of the existing literature regarding race/ethnicity and birth outcomes: First, it uses a propensity scoring estimation method to reassess the differences in birth outcomes across racial/ethnic groups. The result suggests the use of OLS may not be a practical concern, although propensity score estimation shows its own advantages and thus should be used as sensitivity analysis to complement OLS. Second, an examination of biracial infants shows that father's race and ethnicity are relatively unimportant, but the presence of unreported fathers has a strong association with birth outcomes, which might be a source of bias in existing data, and a significant signal of potential post-birth health problems. Finally, this research investigates the competing power of different birth outcome measures as predictors of infant mortality. The results show that the importance of risk factors and birth outcome measures varies by race/ethnicity, gender, and time, which suggests a need to tailor prevention and education efforts, especially during the postneonatal period.

These results, taken in combination, lead to the conclusion that policy makers need to not only continue focusing on closing the recognized gap between black and other

racial/ethnic groups in birth outcomes, but also pay more attention to subpopulations that are traditionally not considered as at risk and certain time periods that are previously regarded as less risky.

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Table of Contents

List of Figures

List of Tables

CHAPTER 1 – Introduction

Intergroup differences in health to some degree reflect unequal life opportunities. Differences in health at birth are especially critical because they may lead to disparities throughout one's whole life. In particular, racial and ethnic disparities in birth outcomes have long been a concern for both researchers and policy makers, partially as a result of changing population composition in recent decades. Whereas about one quarter of the current U.S. population are from racial or ethnic minorities, by the year 2020 it is expected that up to one-third will be; these proportions are even higher for infants and children (DeVita 1996).

It is establish definitions of race and ethnicity in order to properly understand research issues presented in this study. While the definition of race has evolved over time, today's concept, as applied to sociopolitical research, is rooted in the idea of a biological classification based on physical features. Ethnicity, although a related concept, is centered on the idea of social grouping marked by shared culture, nationality, and language use. The U.S. Census Bureau concept of race reflects self-identification by people according to the race or races with which they most closely identify, where these self-identified categories are not meant to be scientific in nature, but rather are sociopolitical constructs[1]. The latest US standards, developed by the Office of Management and Budget (OMB), have five categories for data on race: American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian

[1] U.S. Census Bureau: Race. http://quickfacts.census.gov/qfd/meta/long_68178.htm Last accessed: March 29, 2007

or Other Pacific Islander, and White. There are also two categories for data on ethnicity: "Hispanic or Latino" and "Not Hispanic or Latino." [2]

The long interest and concern with regard to racial and ethnic disparities in birth outcomes also stem from well recognized gaps in health outcomes across groups, particularly the ones between non-Hispanic whites and non-Hispanic blacks. Despite the fact that the United States experienced a rapid reduction in both low birth weight rate and infant mortality during the twentieth century, large disparities in birth weight and infant mortality rates among racial and ethnic groups still persist. Therefore, understanding the reasons for these and other disparities in birth outcomes is a high priority for both policymakers and researchers. For instance, *Healthy People 2010,* a national health promotion and disease prevention initiative developed by the Department of Health and Human Services (DHHS), set a priority goal of eliminating health disparities in the U.S. population, including those due to gender, race, or ethnicity, by 2010. As stated in the document, current information about the biologic and genetic characteristics of different racial and ethnic groups does not explain the health disparities experienced by these groups in the United States; and "these disparities are believed to be the result of the complex interaction among genetic variations, environmental factors, and specific health behaviors" (*Healthy people 2001*).

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[2] Office of Management and Budget (1997). http://www.whitehouse.gov/omb/fedreg/1997standards.html Last accessed: March 29, 2007

Although racial and ethnic disparities in birth outcomes have been widely studied, questions have arisen regarding potential biases in the method most commonly used to analyze these disparities. In particular, since different racial and ethnic groups may be influenced by or interact with risk factors (such as sociodemographic factors or intervening factors) in very different ways, conventional methods such as regressions may yield biased estimation unless they incorporate the possibility of different distributions of factors across groups. This dissertation uses a new analytical approach, propensity scoring estimation, to reassess the differences in birth outcomes in the second chapter, and then assess the ethnic difference in the case of biracial infants in the third chapter. Finally, this study investigates associations between birth outcome measures and infant mortality at different time periods.

In the second and third chapter, I conceptualize birth outcomes (birth weight, low birth weight, Apgar score, and infant mortality) to be the end point of a complicated process that is influenced by several groups of interrelated risk factors. Those risk factors include parental demographics (such as age), socioeconomics (such as income, education), health behaviors (such as smoking, receiving prenatal care), and child characteristics (such as parity). All those factors are found to be influential on outcomes, and will be discussed in detail in subsequent chapters. Race/ethnicity is hypothesized to have independent influence from other included factors on outcomes of interest. This influence is sometimes referred to as the "race effect" in the following chapters, meaning the net effect of being a member of a particular racial and ethnic group on the outcome of interest, after controlling all the observed risk factors. This study aims to better estimate this "race effect" given observed factors.

Nevertheless, this estimated "race effect" on outcomes may take place through genetic, biological, socioeconomic, or behavioral pathways that are not yet captured in currently measured factors. To identify the exact mechanism of this effect is beyond the scope of this study.

In the fourth chapter, infant mortality during the first year of life is conceptualized as the end point of a process, where similar sets of factors mentioned above, as well as race/ethnicity, are deemed to be important risk factors. However, birth outcomes are regarded as the most powerful and proximate risk factors for infant survival chances (Hummer 1999).

In general, this dissertation intends to investigate racial and ethnic disparities in health outcomes at and after birth. Specifically, it answers the following research questions:

1. Are current methods for estimating the effect of racial disparities on birth outcomes biased?
2. Does the choice of study outcome affect conclusions concerning the racial effect on birth outcomes?
3. Are there ethnic differences in birth outcomes among biracial infants?
4. What is the paternal racial effect on birth outcomes?
5. Do racial/ethnic disparities in mortality change over the course of the first year after birth? If so, how?
6. What are the associations between a set of birth outcomes (such as birth weight, gestational age) and infant mortality at different periods (early neonatal [first 7

days since birth], late neonatal [between 8 and 27 days], and postneonatal [between 28 and 365 days])?

Answering these questions will have potentially important influences on maternal and infant health care policy and programs. Specific research and policy implications are discussed in each chapter, and more general conclusions are presented in the final chapter.

CHAPTER 2 – Revisiting the racial and ethnic disparities in birth outcomes

INTRODUCTION

Intergroup differences in health to some degree reflect unequal life opportunities. Differences in health at birth are especially critical because they may lead to disparities throughout one's whole life. On average, birth outcomes in the United States have improved over the past three decades. For example, between 1980 and 2001, infant mortality dropped from 12.9 per thousand to 6.8 per thousand (National Center for Health Statistics 2002). However, despite overall improvement, significant differences in birth outcomes persist across racial and ethnic groups. To cite just one example, between 1970 and 2002, the incidence of low birth weight (LBW) among African American infants in the United States was about 13.2 percent, a figure that is more than twice the 6.5 percent rate for Caucasian infants (DHHS 2004, Conley et al. 2003). Understanding the reasons for these and other disparities in birth outcomes is a high priority for both policymakers and researchers. For instance, *Healthy People 2010,* a national health promotion and disease prevention initiative developed by the Department of Health and Human Services (DHHS), set a priority goal of eliminating health disparities in the U.S. population, including those due to gender, race, or ethnicity, by 2010.

Although racial and ethnic disparities in birth outcomes have been widely studied, questions have arisen regarding potential biases in the method most commonly used to analyze these disparities. To estimate racial and ethnic disparities in birth outcomes (usually between African Americans and Caucasians), researchers typically use multivariate regressions, which control for potentially confounding factors, such as parental education or age. The standard linear regression approach is Ordinary Least Squares (OLS), which models the outcome of interest (e.g., birth weight) as a function of the variable of study (e.g., race and ethnicity), while controlling for all other covariates of interest (e.g., parental education, age, income). However, this method relies on a number of assumptions, some of which have been called into question. For example, OLS assumes that the distribution of background factors is the same across all subgroups. However, it is unclear whether attempts to isolate the effect of race using regression analysis fully account for all potentially confounding variables. As shall be shown in this study, the distribution of several background (covariate) factors (e.g., marital status of mother) for black infants differs greatly from that for either white infants or infants from other racial/ethnic groups. Another cause of concern is that OLS estimation can be highly sensitive to the form of variables used in the analysis and the inclusion of important interactions (Imbens 2003; Ridgeway 2005). For example, the so-called "weathering hypothesis" argues that the disparity in neonatal mortality between black and white infants increases with increasing maternal age, because black infant risk increases with mother's age through the late teens and the 20s, while white infant risk decreases over the same period (Geronimus 1996). Unless all potentially important interactions are modeled, a biased estimation of the racial effect may result.

To overcome these shortcomings, in this study, I estimate the effect of racial disparities on birth outcomes using propensity score estimation, a nonparametric approach that essentially creates a sample of white infants who are from a similar background as that of observed black infants. The only observed attributes that differ between the two groups, by design, should be race and birth outcomes. Using this method, I will examine whether the use of OLS for estimating the effect of racial disparities on birth outcomes leads to biased results.

Birth weight gap across ethnic groups

Birth weight, which is considered to be the single most important factor affecting infant mortality and childhood morbidity, has long been a subject of clinical and epidemiological investigations and a target for public health intervention. Considerable attention has been focused on the category of low birth weight (LBW), which is defined as a birth weight less than 2,500 grams. Currently 7.6 percent of births in the United States, or about 250,000 infants each year, are LBW, and of those, a fifth are born with very low birth weight (less than 1,500 grams). [3] Since LBW has been linked to infant mortality and numerous childhood setbacks, resources used to care for LBW infants are considerable, accounting for about 10% of all health care costs for children, according to Lewit et al. (1995). A 1988 assessment showed that health care, education, and child care costs were $5.5 to $6 billion higher from birth to age 15 for the 3.5 to 4 million children born with LBW than for those children with normal birth weight (Almond et al. 2002).

Notwithstanding improvement in healthy birth outcomes in the United States (for example, infant mortality has dropped from 12.9 per thousand to 6.8 per thousand between 1980 and 2001 [National Center for Health Statistics 2002]), there are still major and

[3] The current cutoff point of 2,500 grams was derived from studies of Caucasians in early 1900s, and then adopted by the World Health Organization in 1950 as a universal definition of LBW, although this threshold has long been criticized as arbitrary and problematic by researchers.

continuing disparities in birth weight by both race/ethnicity and socioeconomic status (SES). As already noted, between 1970 and 2002, the incidence of LBW among African American infants in the United States was about 13.2 percent, which was more than twice the 6.5 percent rate for Caucasian infants (DHHS 2004, Conley et al. 2003). Further, the LBW rate rose from 7.7 to 7.8 percent between 2001 and 2002, the highest level reported in more than 3 decades, mostly due to the rise in the multiple births. A recent study argues delayed child bearing may also play an increasingly important role in LBW trends in the U.S. (Yang et al. 2006). LBW increased from 6.8 to 6.9 percent among non-Hispanic white births, and from 13.1 to 13.4 among non-Hispanic black births, not only largely erasing the recent modest downturn (from 13.6 percent in 1991) but also widening the racial gap in birth weight (Martin et al. 2002).

Consistent with Sastry's observation (2002), two aspects of the birth weight distribution (Figure 1) lead to such a high LBW rate among African Americans. First, African Americans have a lower average birth weight: in 2001, the mean birth weight for non-Hispanic blacks was 3,113 grams, about 11 percent lower than the mean birth weight of non-Hispanic whites, 3,467 grams. Given the bell-shaped distribution of birth weights, this lower mean translates into a larger fraction of births to non-Hispanic blacks falling below the 2,500-gram threshold. Second, the standard deviation in birth weight for blacks is 637 grams, about 7 percent larger than the standard deviation of 597 grams for whites. Thus, even if the means were the same, a higher fraction of black births would be classified as LBW.

Explanations of the birth weight gap

The relationship between social disadvantage and LBW has been examined in numerous studies. For instance, Parker et al. (1994) evaluated the associations between LBW and five indicators of socioeconomic status (maternal education, parental education, maternal occupation, parental occupation, family income) in a representative sample of U.S. births from the 1988 National Maternal and Infant Health Survey. Nearly all of the socioeconomic indicators used were significantly correlated with LBW among both black and white women.

Given that race/ethnicity is usually highly correlated with socioeconomic status, a large body of research has tried to explain the racial disparity in birth weight as the result of differences in socioeconomic status. However, Berg et al. (2001) and Foster et al. (2000) remarked that disparities in the VLBW rate or LBW rate between blacks and whites remained even after accounting for SES. A number of studies have confirmed that race and socioeconomic status had separate, independent effects on LBW rates (Boardman et al. 2002, Morenoff 2003, Pickett & Pearl 2001).

However, most studies showing independent effects of race and SES used OLS, which has led to concerns about potential bias. In particular, the estimate of the race effect is sensitive to model misspecification when the distribution of all covariates (such as socioeconomic status) is not the same across all subgroups, leading to a biased estimation of the racial effect. As discussed in more detail below, demographers have proposed several alternative approaches to decompose the disparities in health outcome across groups, and I demonstrate a nonparametric approach to assess the racial effect.

Purpose of this study

This study examines racial and ethnic disparities in several birth outcomes (birth weight, LBW rate, and 5-minute Apgar score; the latter a routinely performed means of evaluating the general physical condition of the newborn at five minutes after delivery), using propensity score estimation, an alternative nonparametric approach that overcomes theoretical concerns with the OLS technique. Several key questions are addressed regarding the choice of analytic approach and choice of outcome of interest.

First, are current methods for estimating the effect of racial disparities on birth outcomes biased? In this study, the propensity score method is applied to nationally representative data from the 2001 Early Childhood Longitudinal Study, Birth Cohort (ECLS-B), in order to weight the empirical distribution of all covariates in the comparison and reference groups and to create a sample of white (or Hispanic of Mexican origin) infants with backgrounds similar to those of the observed black infants. This direct comparison of the groups provides a true indication of the racial/ethnic effect on birth outcomes. Because there is inherent heterogeneity within the Hispanic population, only Hispanics of Mexican origin are analyzed in this study.

Second, does the choice of study outcome affect conclusions concerning the racial effect on birth outcomes? Because birth weight, LBW rate, and 5-minute Apgar score in effect measure different health outcomes at birth, and also because LBW cutoff is to some degree artificially set for all racial and ethnic groups, a closer examination on each outcome is necessary, and will inform researchers and policymakers as to the consequences of selecting one or more indicators for intervention.

DATA

This study uses 9-month data from the Early Childhood Longitudinal Study, Birth Cohort ECLS-B, a nationally representative sample of 10,688 children born in the United States in 2001. The data intentionally oversampled Chinese and other Asian and Pacific Islander children, American Indian children, twins, and children with moderately low and very low birth weight (ECLS-B manual). This data set has several strengths: it provides a nationally representative sample from a recent year; it links the data to the child's birth certificate, thus reducing concerns of "recall bias" regarding birth outcomes; and it provides abundant socioeconomic information. However, one limitation of using this data set is that it includes data only from children who survived at least 9 months after birth. Therefore, the birth outcomes in this study are more favorable than the actual national birth outcomes since birth outcomes are adversely correlated to infant mortality. (Infants who died in the 9 months since birth constitute 0.6% of all live births in 2001.[4]) In this study, I adjusted the data for sampling weights, so the results should be nationally representative.

[4] This percentage represents infants died equal or less than 270 days, calculated from National Center for Health Statistics Birth/Death linked data file for 2001.

Choice of covariates

After weighting the racial/ethnic groups' covariates by propensity score, the two groups by definition should have no difference except for race and the outcome of interest. A set of covariates used to match the comparison groups was carefully selected, as discussed in detail immediately below, because covariates may be related to the outcome of interest, birth weight. The covariates are grouped in three primary categories: mother's background, child's information, and family background. The same variables are included in both OLS and propensity score estimation.

Mother's background includes mother's biological, socioeconomic, and behavioral variables, such as age, weight before pregnancy, height, education (years of schooling), marital status, birthplace, and number of prenatal visits. Maternal educational attainment has been shown to have a profound effect on the number of births and the risk of adverse birth outcomes (Martin JA., et al. 2002). Children born to unmarried mothers have been found to have a higher LBW rate (Hessol et al. 1998). There is evidence that prenatal care can enhance pregnancy outcomes by providing health care advice and managing chronic and pregnancy-related health conditions (CDC 2002).

Child's information includes child's sex, gestational period, total birth order, and plurality of birth (i.e. whether or not the baby was a plural birth). Female infants on average are smaller than male infants. Gestational period has been found to be highly associated with birth weight. Research has shown that first-born children have a higher risk of LBW (e.g.

Miller 1994). Plurality of birth is strongly related to birth weight: 55.4% of twins and 94.4% of triplets are LBW by the current LBW standard (CDC 2002).

Family background includes SES, poverty level[5], and county population size. Socioeconomic status (SES) [6] is a measure of social standing that implies parents' access to resources and ability to purchase health care services. The SES variable reflects the socioeconomic status of the household at the time of the 9-month parent computer-assisted personal interviewing (CAPI) instrument. The components used to create the measure of SES include father/male guardian's education, mother/female guardian's education, father/male guardian's occupation, mother/female guardian's occupation, and household income. The form of SES used is the average of these five measures, each of which was standardized to have a mean of 0 and a standard deviation of 1, so SES is a continuous variable that is ranging from –2.10 to 2.25. Children are considered to be poor if they live in families with incomes below the poverty threshold for a family of their size. The ECLS-B estimated childhood poverty by

[5] Household income, a variable with 13 levels ranging from $5,000 to $200,000 and above, was also considered. However, the variable of household income was used to generate variables of SES and poverty and therefore was highly correlated to both of them. I decided to only include SES and poverty into the two models: when checking the collinearity between mother's education, SES, and poverty, the *condition number*, a commonly used index of the global instability of the regression coefficients, was 13.9, which indicates some concern of multicollinearity. See detailed descriptions in ECLS-B manual: Early Childhood Longitudinal Study, Birth Cohort (ECLS-B) User's Manual for the ECLS-B Nine-Month Restricted-Use Data File and Electronic Code Book.

[6] Note that ECLS-B only collected data for those infants who survived for at least 9 months, which could introduce upward bias of social standing, if we assume that infants who died before 9 months are more likely to come from disadvantaged families.

comparing parental reports of income against the 2000 weighted poverty thresholds published by the U.S. Bureau of the Census (ECLS-B manual).

Outcomes of interest

Outcomes of interest include birth weight, LBW, and 5-minute Apgar score. Birth weight is a continuous variable, equivalent to the measured weight in grams, at birth. LBW is a created indicator variable that takes on a value of 1 when birth weight is less than 2500 grams. The 5-minute Apgar score (developed over 50 years ago by Dr. Virginia Apgar) is a routinely performed means of evaluating the general physical condition of the newborn at 5 minutes after delivery. The score measures five easily identifiable infant characteristics—heart rate, respiratory effort, muscle tone, reflex irritability, and color, on a scale of 0,1 or 2, with 2 representing optimum behavior for each sign. The Apgar score is the sum of the scores of the five components, and a value in the range of 7-10 is considered normal (CDC 2002).

METHOD: PROPENSITY SCORE ESTIMATION

This study compares propensity score estimates (Rosenbaum and Rubin 1983) of birth weight disparities between racial/ethnic groups with the results produced by the conventional approaches (i.e. OLS, logit model). Demographers have long discussed how to decompose the mean difference of a given variable between groups (Barsky et al. 2002), and propensity scoring is one of the proposed nonparametric alternative approaches.

A possible alternative to the conventional OLS estimation is Blinder and Oaxaca decomposition, which is often used to investigate income gaps between groups. This approach decomposes the mean difference of a given variable between groups into the portion attributable to differences in the distribution of some explanatory variables and the portion attributable to differences in the conditional expectation functions. However, the Oaxaca decomposition, like OLS, also requires that a parametric assumption be made about the form of the conditional expectations function.

While the use of propensity scoring is becoming an increasingly common analytical approach generally, it has not yet been used to assess racial differences in birth outcomes. Using this approach enables one to compare racial effects on birth outcomes directly, thus examining the validity of concerns regarding the use of conventional approaches, such as OLS and logit models.

Benefits of using propensity score analysis

As shown in Table 1, the distribution of background (covariate) factors for black infants differs greatly from that for either non-Hispanic white infants or Mexican infants. For example, black mothers had a very low marital rate of 32%, compared to 78% for white and 62% for Mexican. Average maternal age was significantly higher for white mothers (28) than for the black and Mexican mothers (25 and 26, respectively). Black mothers' average pre-pregnancy weight was considerably higher (156 pounds) than that of the other two groups (148 pounds for white mothers and 141 pounds for Mexican). Only 41% of Mexican mothers were born in the United States, compared to 89% of black mothers and 96% of white. White mothers were much better off than the other two groups both in terms of SES and poverty level.

As a result of these differences, it is unclear whether a significance test of the race coefficient can sufficiently account for these potentially confounding variables. Thus, in this study, the propensity score method essentially creates a sample of white infants who are from a similar background to that of the observed black infants. That is, after weighting, the empirical distribution of all covariates (e.g., parental bio-features and SES) should be similar across groups. The only observed attributes that differ between the two groups, by design, should be race and birth outcomes. So the estimated race effect is the "treatment effect on the treated" (Imbens 2003).

In contrast to OLS, which requires multiple iterations of model specification to produce various combinations of interactions and non-linear transformations of independent variables, propensity scores were estimated using a nonparametric regression technique that minimizes imbalance in the covariate distributions between the groups as much as possible. This technique is the generalized boosted model (GBM, Ridgeway 2005), a general multivariate data-adaptive modeling algorithm that can estimate the nonlinear relationship between a variable of interest and a large number of covariates of mixed type (binary, ordinal, continuous), while also allowing for flexible, non-linear relationships between the covariates and the propensity score (Ridgeway 2006).

Propensity score adjustment

Propensity score analysis, in contrast, offers a transparent analytical tool that can be used to adjust for confounding factors (Rosenbaum and Rubin 1983). The propensity score is the probability that a subject with a set of covariates appears in the reference group, denoted as

p_i = P(r=1 | X_i), where X_i refers to the observed covariates for person i; r denotes race, r=1 indicates blacks, r=0 indicates non-Hispanic whites. Though this score per se is not the focus of this study, it helps to match the two groups based on those observed covariates. Propensity score weighting (Rosenbaum 1987; Wooldridge 2002; McCaffrey, et al. 2004) is the process of applying weights to each subject in the comparison group (whites in this case). The weights, calculated as $p_i/(1 - p_i)$, are the odds that a randomly selected participant with features of X_i would belong to the reference group (blacks in this case). Each subject in the reference group receives a weight of 1 and each subject in the comparison group is weighted by the odds of membership in the reference group. In this study, white infants are one of the comparison groups. Those white infants with similar background features as black infants are most like those in the reference group; therefore, they receive higher propensity scores and also higher weights. Conversely, those white infants who have very dissimilar characteristics from black ones will have p_i near 0, and thus they get nearly zero propensity score weights. In this way, the weighted joint distribution of the comparison group's features will be identical to the joint distribution of the reference group's features. Therefore, we will be able to compare black infants to white infants who have exactly the same background.

Development of comparison groups

In order to investigate the discrepancy in birth weight between whites and blacks, I introduced an indicator variable of black mothers as the reference group (with white mothers as the comparison group). Studies of infant birth weight typically use maternal race instead of child's race because child's race may not be clear in the case of intermarriage. Mother's race is speculated to have more influence on birth weight than father's race (Migone et al. 1991). To examine the racial effect across a wider spectrum, this study also includes Mexicans as a second comparison group. Mexicans constitute the largest group of Hispanics in the dataset and in the United States. I created a race indicator variable of black (vs. Mexican) and an indicator of Mexican (vs. black). "Mexican" refers to Hispanics of Mexican national origin.

Based on every observation's covariates, I estimated the odds that each observation in the comparison group (whites or Mexicans) could be in the reference group (blacks). For example, assume there are 100 infants from poor families with matching values for all covariates. Among the 100 are 60 black infants and 40 white infants. The probability of being in the black group is 0.6, yielding a propensity weight of 0.6/(1-0.6) = 1.5 for any of the 40 white infants. After this step, the weighted statistics (such as mean) of the comparison group will be the same as the unweighted statistics of the reference group. In this simple example, the weighted percentage of infants from poor families in the white group (1.5*0.4=0.6) is the same as in the black group (0.6). Using this method, the effective sample size (ESS) of the weighted comparison group was calculated as $(\sum Wi)^2 / \sum Wi^2$, and is presented in Table 1. McCaffrey et al. (McCaffrey, et al. 2004:406) defined ESS as "approximately the number of observations from a simple random sample needed to obtain an estimate with sampling variation equal to the sampling variation obtained with the weighted comparison observations. Therefore, the ESS gives an estimate of the number of comparison participates that are comparable to the reference group."

After the propensity score weights have been applied, as described above, the only observed differences between the two groups should be race and, potentially, outcomes (if these differ significantly by race). Since each covariate has the same distribution across both groups after weighting, the difference in the average outcome between the two groups, which can only be attributed to race, is the "race effect."

RESULTS

Results are presented in five subsections as follows: the first subsection demonstrates how propensity-score weighting changes the distribution of covariates of comparison groups (whites and Mexicans) to match with the reference group. The second subsection compares birth outcomes across racial/ethnic groups before and after weighting. The third subsection compares results from the two approaches: propensity score estimation and the conventional (OLS) approach. The last subsection discusses the potential effect of paternal background on birth outcomes.

Distribution of covariates for blacks, whites, and Mexicans

Table 1 presents the original distribution of covariates in the reference group (black) and comparison groups (white and Mexican), and Table 2 demonstrates how propensity-score weighting changed the distribution of covariates in the two comparison groups. For example, before applying the propensity score weight, 78% of the white mothers in the comparison group were married, compared to 32% of black mothers and 62% of Mexican mothers. Only 41% of Mexican mothers in the comparison group were born in the United States, compared to 89% of black mothers and 96% of white mothers. After applying weights derived from the propensity scores, we created a virtual comparison group of white infants and a virtual comparison group of Mexican infants that closely matches the black infants in terms of background factors. Table 2 shows that, after applying the propensity score weights, 33% of the weighted white mothers in the comparison group were married (close to the 32% rate for black mothers) and 87% of the weighted Mexican mothers were U.S. born (close to the 89% rate for black mothers).

At the bottom of the table are the infant's gender and rate of plural birth. These changed little after weighting because, as predictors, they contributed the least in the propensity score model. The proportion of female or singleton infants doesn't change after weighting, which is expected because baby's gender or likelihood of being a multiple births normally is random and independent of race[7], so it ought to have a similar distribution within each racial group. Table 3 confirms that gender is random in this data set, by creating a new set of propensity scores and weights using female infants as the reference group and males as the comparison group. Covariates are distributed in similar patterns for boys and girls, and the effect of weighting can be seen to be almost 0. Note that the effective sample size was in fact the real sample size of male infants.

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[7] However, in recent years, use of fertility drugs has led to much higher chance of having plural births. Therefore, differential use of fertility drugs across racial groups would lead to the odds of plural births somehow dependent of race/ethnicity.

Comparison of birth outcomes across groups

Table 4 presents birth outcome comparisons across racial/ethnic groups before and after applying weights derived from the propensity scores. As expected, large gaps exist between black and white infants for each birth outcome: A raw comparison without controlling for any covariates (i.e., before applying propensity score weights) shows that the average birth weight for white infants is 3,378 grams, about 261 grams more than that for black infants (3,117 grams), while the LBW incidence for white infants is 6.4%, compared to 11.8% for blacks. After applying propensity score weights, the outcomes did not significantly change in spite of substantial changes in the covariate distributions: now the mean birth weight of white infants is 3,339 grams and the difference in birth weights between blacks and weighted whites is 222 grams, only 39 grams less than the original difference of 261. The difference in LBW rate decreases by 1.5, from 5.4% to 3.9%. Thus, assuming that we have captured all the important covariates, the effect of being black compared to white on birth weight is 222 grams, and on LBW prevalence is 3.9%.

Matching Hispanic infants of Mexican origin with blacks yields similar results, as shown in Column 7 of Table 4: after matching, Mexican infants' average birth weight increases marginally by 28 grams, from 3327 grams to 3355 grams, and LBW rate remains the same. That is, matching covariates only slightly closes the gap in birth weight or LBW rate between blacks and whites, while in the case of blacks and Mexicans, matching covariates *widens* the gap in birth weight.

5-minute Apgar scores show very different results: even before applying propensity scoring, mean Apgar score is in fact the same across racial/ethnic groups and changes very insignificantly after weighting. One caveat before discussing the discrepancy between birth weight outcomes and Apgar scores is that the samples are different: since California and Texas do not require Apgar score on birth certificates, these two states, both of which have a large population of Mexican origin, were excluded from the Apgar score sample. Nevertheless, unless Mexicans in these two states are considerably different from their counterparts in other states (there is no empirical evidence[8] or theoretical reason to believe this is the case), we observe no racial/ethnic disparity in Apgar scores across the three groups. This discrepancy between birth weight and Apgar score is primarily a result of the sampling strategy of this particular data (ECLS-B), and this discrepancy is further discussed in the next section.

Hispanic infants of Mexican origin and white infants can also be directly compared, using Hispanic infants as the reference and white infants as the comparison group. Mexicans' original mean birth weight is 3327 grams, or 50 grams less than the white infants. This difference is statistically significant. After weighting, however, Mexicans get a slightly better outcome. Table 5 shows a summary of all three racial effects. The last row in the birth weight section shows that the average birth weight of Mexicans is now 36 grams less than that of whites, and this difference is no longer statistically significant. Similarly, the LBW rate for Mexicans is lower than that for whites after applying propensity-score weights. The results can

[8] Since I use a smaller sample for Apgar score estimation, I repeated analysis of birth weight and LBW rate using this sample. The effect of being black on birth weight is –206 grams and on LBW rate is 5.40%, basically the same as otherwise using the full sample (-200 grams and 5.39% as showed in Table 3).

be interpreted to mean that, Mexican infants with exactly the same observed background as white or black infants have a higher or same average birth weight. Though the difference is marginal when comparing Mexicans to whites, this finding is consistent with the so-called "Hispanic paradox" (Frisbie et al. 1996; Sastry and Hussey 2002). i.e., that Mexicans in the United States have better health and mortality than expected given their low social and economic status. Since we matched Mexican mothers' birthplace with that of black or white mothers, this small advantage cannot be explained away by the "healthy migrant" hypothesis that Mexican migrants to the United States self-select for good health.

Comparison between the propensity score method and conventional methods

The study also compared results using the propensity score method with those using conventional methods, which in this case refer either to OLS, the standard linear regression procedure, using birth weight as the dependent variable; or to logit regression, using LBW as the dependent variable. In both cases, race (black in this case) would be the indicator variable, while all of the covariates would serve as independent variables. Table 5 compares the results of the propensity score weighting and the convention method (OLS or logit) on the three possible outcomes: birth weight, LBW, and Apgar scores. Each model estimates the racial effect on birth outcomes after controlling for the same set of covariates.

Fitting the OLS model yields a racial effect of 200 grams, meaning that compared to white infants and holding everything else constant, being black decreases birth weight by 200 grams, a smaller effect than found in the propensity score-based estimation of 222 grams. This result is consistent with Sastry and Hussey's previous research (2003), which found that the racial effect of being black on birth weight was 183 grams. This difference was calculated by subtracting the observed mean birth weight for blacks from the predicted mean birth weight for whites, where the prediction matched the effect on birth weight of white and black infant background and intermediate characteristics (Sastry & Hussey 2003). The two methods show a difference in the birth weight racial effect (black vs. white), with OLS estimating a value of 22 grams less than propensity scoring. However, this difference is not statistically significant since the effect produced by propensity scores (222 grams) falls into the confidence interval of the effect generated by the OLS model. The racial effect on birth weight of being black compared to that of being Mexican is also quite large using conventional methods: 195 grams using OLS or 238 grams using propensity score. In this case, the difference between the two methods' results is also not statistically significant, as the 95% OLS confidence interval for the effect ranges between –251 grams and –139 grams, and thus includes the propensity score estimate of 238 grams. This result, nevertheless, combined with the result of black and white comparisons, may indicate that the racial effect of being black is slightly *underestimated* by OLS.

Section II in Table 5 compares the *LBW rate* estimates found by the propensity score and logit methods. Propensity score estimation finds the LBW prevalence in the black population is 3.9% higher for blacks than for whites with matched backgrounds, while the logit model predicts that the black group would have a 5.39% higher LBW rate than whites. This result, with propensity score estimation yielding smaller racial effects from being black (*vs.* white or Hispanic) compared to the predictions of the logit model, is *counter* to the previous findings examining the birth weight outcome. Although the differences in birth weight or LBW rate between the two approaches are not generally significant, the opposing direction of effect for the two outcomes suggests the need for care in choosing birth weight or LBW rate as a measure for birth outcomes, since they may lead to different conclusions. This result may also suggest LBW threshold should be different for the two groups.

Potential paternal effect on birth outcome

This study so far has estimated the racial difference in birth weight by using three methods: propensity-score estimation, OLS, and logistic regression. However, the results of these methods are very sensitive to omitted variable bias: omitting important factors will lead to difficulty in differentiating the racial effect from the effects of the omitted variables. An example of a real omitted variable is father's information, which was not included or controlled for in this study due to data scarcity. Indeed, very few studies have included father's biological factors in birth weight investigations, despite the reasonable expectation that fathers will affect LBW status. Conley and Bennett argued that there might be an intergenerational legacy that infants to some degree inherit both mothers and fathers' LBW status, through genetic, parental behavioral or environmental mechanisms (Conley & Bennett, 2000). Additionally, it is conceivable that a father's biological features, such as age, weight, and height may also affect infant's birth weight. In fact, a recent study identified paternal age as an independent risk factor for LBW in the U.S. urban population: fathers older than 34 years were found to be 70% more likely than fathers aged 20 to 34 years to have LBW infants, after controlling for child's gender and mother's age, race/ethnicity, birthplace, parity, marital status, and health insurance type (Reichman et al. 2006).

The ECLS-B dataset used in this study provides some information on fathers' background that can be used to provide a preliminary look at the effect of fathers' characteristics on infant birth weight. The data include "Father Self-Administered Questionnaires", which capture information about the activities fathers engaged in with their children and their attitudes toward fatherhood. Fathers also provided key information about themselves, such as their age, weight, and height. However, fathers' information is available for only 74% of the infants, and the results varied widely by race/ethnicity: for example, only 35% of black mothers' spouses or partners completed father's questionnaires compared to 65% for the white mothers. The low response rate for black fathers is related to the low marriage rate among black mothers: only 31% of black mothers were married compared to 77% of white mothers. Since the missing data are related to other variables (e.g. marriage), they are not completely missing at random.

My preliminary test finds that, in each racial and ethnic group, the mean birth weight of the group with father's information is equal or higher than the mean birth weight of the group without father's information. Since we cannot reject the hypothesis that infants with fathers' information are better off than those without fathers' information just for being in the former group, which may be a proxy for other profound factors such as father's SES and family support, when including available fathers' information to analysis, we are not able to distinguish the effect of having fathers around *per se* from the effect of father's biological features. Therefore, both including father's biographical information and utilizing data imputation may introduce bias. Just to investigate whether including father's biological features would make any difference, I conducted a simple experiment that used dummy variable adjustment for the missing values in the OLS model (i.e. including a dummy indicator for the cases where father's information is missing), and found that both father's weight and height were significantly associated with birth weight, while father's age was not. The effect of being black on birth weight in this new model remained large (181 grams) and was *not statistically* different from the previous estimate, which did not account for father's information (200 grams, as showed in Table 4). Thus, father's information seems to explain the birth weight gap to certain degree, and the results reported previously slightly (*not statistically*) overestimate the racial effect on birth weight. Since dummy variable adjustment for missing values is known for producing biased coefficients, one should use more sophisticated approaches to impute or adjust for missing values of father's features; however, to estimate the exact influences of fathers on infant health is beyond this study's scope.

DISCUSSIONS/CONCLUSIONS

This study used a novel approach, propensity score estimation, to examine differences in birth outcomes across racial and ethnic groups in the United States in 2001, and compared these results to the standard parametric estimation approach, OLS. Despite theoretical concerns regarding the use of OLS, this study found a large racial gap in birth outcomes regardless of which method is used. When mother's biological and family's socioeconomic factors are controlled for or matched, being black explains the largest portion of the gap in birth outcomes: before controlling for the covariates, the birth weight gap between whites and blacks is 261 grams, while after controlling for the covariates the gap is reduced to 222 grams. This 15% reduction can be interpreted as the percentage of the birth weight gap explained by the controlled demographic and socioeconomic factors, while the remaining 85% of the gap appears to be explained by race/ethnicity. One likely possibility for the apparent large racial effect is that not every relevant factor was controlled in this analysis. For example, a previous study by Morenoff investigated neighborhood effects on birth weight and showed that neighborhood mechanisms and spatial externalities are both important for understanding the influence of the social environment on infant health, even after controlling for individual-level covariates (Morenoff 2003). Using data from 1990 births in Chicago, Sastry and Hussey found that the observed mean birth weight for blacks was 183 grams less than the predicted mean birth weight for whites if the effects of their (background and intermediate) characteristics on birth weight were the same for both groups (Sastry and Hussey 2003). The similarity in magnitude of those findings with the ones reported here suggests that the neighborhood effect, as estimated by Sastry and Hussey is, to some degree a proxy for individual-level socioeconomic status that was used here but not included in Sastry and Hussey's study. Another study by Shiono and colleagues (1997) found that after controlling a set of risk factors that differ from those included either in this study or Sastry and Husses's paper, (such as living in public housing), black infants were on average 236 grams lighter than white infants, which is quite close to what we find in this study. Therefore, the degree to which those omitted variables can further explain the gap in outcomes is unclear, given that we have already included the factors (e.g. maternal race/ethnicity, age, baby's gender) that previous research has identified as most important. Unless we find other factors that could explain away the gap to a very large degree, the racial/ethnic effect will remain enormous.

When comparing propensity score estimation and the conventional methods (i.e. OLS, logit model), despite those theoretical concerns regarding OLS, we did not find significant differences between the results produced by the two methods except for statistically *insignificant* differences. For instance, the propensity score method estimates that being black results in infants who are 238 grams lighter at birth weight than Mexican infants with the matched backgrounds, and this effect is different from the OLS estimate of 195 grams. In theory, if effects of covariates were truly linear, one would expect the two approaches to yield the same results. Therefore, the difference in the results of the two approaches in this case might indicate that certain covariates have nonlinear forms but were being modeled as linear. To investigate the extent to which the effects of continuous covariates are not linear and how might this nonlinear form affect the result, based on previous studies and preliminary modeling, I replaced the linear forms of some covariates in the original OLS model with nonlinear forms as following: maternal age is now categorized as younger than 20 years, 20 to 34 years (reference group), or 35 years and older; maternal education is classified as less than high school, high school, or some college and beyond; birth order is grouped as first birth (reference group), second birth, or third and higher birth; finally gestational age is categorized to early (less than 37 weeks), on time (between 37 and 44 weeks, reference group), and late (more than 44 weeks). The new regression including those nonlinear forms estimates the effect of being black (vs. Mexican) is 220 grams, which is closer to the propensity score estimate of 238 grams. Introduction of these nonlinear forms did not statistically change the estimate of OLS in the case of blacks and whites comparison.

Based on the covariates included in this study, we may conclude that the use of the conventional approach is not a real concern in practice. Therefore, if researchers are interested only in the magnitude of the racial effect on birth outcomes, not in the pathway or causality, the use of conventional approaches should not be a serious concern, although researchers need to be careful with their choice of covariates and possible omitted variable bias. A comparison between propensity score estimation and conventional approaches would be needed if another set of reasonable covariates were identified and added to the model. Nevertheless, the propensity score approach shows practical advantages: since the nonparametric modeling used in this study to estimate propensity score automatically selects nonlinear transformations and interactions, one doesn't need to fit several OLS models with various combinations of interactions and non-linear transformations of independent variables.

Despite the marginal differences in the results of the two methods, the study does indicate that the choice of birth outcome can affect the conclusion. For example, the propensity score estimation found that the racial effect of being black on birth weight is larger than that resulting from the OLS model, but that the racial effect on LBW rate is smaller than that resulting from the Logit model. Given that the LBW threshold is set arbitrarily, a study that measures LBW incidence should complement this outcome with birth weight.

Finally, Apgar score as a birth outcome of interest deserves more attention. As previously discussed, there is a large racial/ethnic disparity in observed birth weight and this disparity remains even after controlling for an array of covariates, but there is no evidence of disparity in Apgar scores across racial/ethnic groups, before or after accounting for confounding factors. This discrepancy should *not* be interpreted as suggesting that the birth weight disparity across racial/ethnic groups does not matter. In fact, this discrepancy between birth weight and Apgar score is primarily a result of the sample of ECLS-B data: this data set includes only children who survive at least 9 months after birth. Several previous studies have demonstrated that Apgar score is a strong predictor for infant mortality, independent of birth weight, gestational age, and a large number of control variables (Doyle et al. 2003, Almond et al. 2005). In light of these findings, we should not expect much variation in Apgar score for children who survive at least 9 months. On the other hand, among surviving infants with similar Apgar scores, a large disparity in birth weight still remains across racial/ethnic groups. This may suggest that Apgar score is a good predictor for immediate outcomes (e.g. infant mortality) while birth weight may be a better predictor for longer-term outcomes, given that the association between birth weight and teenage/adulthood health outcomes has been well established by previous research.

These findings shed light on both research and policy domains. Results of this study suggest that the use of OLS may not be a practical concern, but propensity score estimation shows its practical advantages. Furthermore, discrepancy between birth weight, LBW rate, and Apgar score as outcomes is found. This has a particularly noteworthy implication of which indicator should be used for a certain intervention. For instance, Apgar score may be a better indicator to use for neonatal mortality risk and birth weight might be an appropriate one to use for longer term interventions. Finally, the results of the large remaining racial/ethnic disparity in birth weight, after accounting for confounding factors regardless of which method was used, suggest more effort is needed to investigate the physiological pathways, by which these disparities are created.

CHAPTER 3 – Racial/ethnic disparities in health outcomes of biracial infants

INTRODUCTION

Notwithstanding great improvement in healthy birth outcomes in the United States (for example, infant mortality dropped from 12.9 infant deaths per thousand live births to 6.8 per thousand between 1980 and 2001 [NCHS 2002]), significant and continuing differences persist across racial and ethnic groups. In 2004, the low birth weight (LBW, defined as a birth weight less than 2,500 grams) rate was 7.2% for non-Hispanic white infants but 13.7% for non-Hispanic-blacks; the white infant mortality rate was 5.65 per thousand, but 13.65 per thousand for blacks (Hamilton et al. 2005; Miniño et al. 2006). These disparities are believed to result from complex interactions among genetic variations, social and environmental factors, and specific health behaviors (*Healthy People* 2010; Kogan 1995; Kramer 1987).

Numerous studies have investigated the magnitude of racial and ethnic disparities in birth outcomes, while controlling for parental biological features other than race and ethnicity (such as parental age, height, and weight), family socioeconomics (such as parental education or family income), and other environmental factors such as neighborhood characteristics. A consensus has emerged that the birth weight gap between non-Hispanic blacks and non-Hispanic whites remains *significant*, despite being largely reduced through accounting for known risk-factors (Berg et al. 2001; Foster et al. 2000; Boardman et al. 2002; Morenoff 2003; Pickett & Pearl 2001). Although a large body of research has speculated about and examined potential pathways and explanations, the exact causes and magnitude of this racial/ethnic effect remain unknown and a matter of dispute.

Most previous research, when referring to race/ethnicity, used maternal race and ethnicity instead of infant race/ethnicity both because the child's race may not be clear in the case of mixed-race parents, and because mother's race/ethnicity is thought to have more influence on birth weight than father's race/ethnicity (Migone et al. 1991). Furthermore, father's information was often not available in the data sets of choice. This common practice might be a serious analytical shortcoming since it overlooks the father's effect and it treats interracial infants and those infants of endogamous marriages/cohabitants equally. When data for fathers are available, one can simply include father's race as an indicator variable and assess the effect of father's race/ethnicity on outcomes of interest. However, this approach assumes that there is no difference between mixed-race parents and same-race parents, except for race/ethnicity; otherwise it should allow covariates (e.g. SES) to have different coefficients for each different family type. In fact, many studies have shown very different patterns in terms of socioeconomic characteristics between intermarriage and endogamous marriage in the U.S.: As Fu (2001) found based on the 1990 U.S. census data, black or Mexican husbands' white wives had less schooling than white husbands' white wives. Fu explained this pattern using both the status exchange and in-group preference hypotheses. Status exchange hypothesizes that members of a society generally agree on the relative social status of each racial group. Therefore, in a marriage market framework, black or Mexican men are from lower status groups, and will be less desired as partners than white men. They will therefore marry to less desired white women (e.g. lower education). The second hypothesis, in-group preference, simply suggests that people prefer members from their own group, and thus intermarriage is the least desirable scenario. In light of these hypotheses, this study will examine whether we can treat mixed parents and homogenous parents the same way.

According to the National Center for Health Statistics (NCHS) natality files that contain statistical information from birth certificates, between 1968 and 1996 the proportion of infants born to one black and one white parent increased gradually from 0.33% to 1.77%, and the proportion of interracial marriages between Asians/Pacific Islanders and whites also increased from 0.25% to 1.21 (Parker et al. 2002)[9]. These infants of intermarriages provide a unique chance to investigate both maternal and paternal effects on birth outcomes. To date, only a few studies have examined birth outcomes of interracial infants and all of these studies focused on black and white mixed infants, mostly due to the smaller number of infants of other mixed races. Together they found that mixed-race couples differed significantly with respect to their sociodemographic variables from those of the endogamous couples. After controlling for sociodemographic and behavioral variables, biracial infants had a lower average birth weight, a higher LBW rate, and higher risks for both stillbirth and infant mortality than white/white infants, but they had better results than black/black infants (Getahun et al. 2005; Hessol et al. 1998; Collins et al. 1993; Migone et al. 1991; Parker 2000; Polednak & King 1998).

However, these previous studies have several limitations. First, they didn't examine racial and ethnic groups other than black and white. Second, when using natality data, father's

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[9] These percentages are lower bounds on the estimates of interracial births: father's race was missing on about 7% of birth records in the late 1960s and 15% in the late 1980s; when the father's race was missing, the father was assigned the race of the mother (Parker et al. 2002).

information is often missing, especially for black mothers (due to low marriage rates) under 25 years old. These infants are more likely to have disadvantaged birth outcomes (Martin et al. 2003; Hessol et al. 1998), but this group is often conveniently omitted from studies. Third, none of these studies examined Apgar scores (a routinely performed means of evaluating the general physical condition of the newborn at 5 minutes after delivery) as a birth outcome, even though it has recently been found to have stronger predictive power for infant mortality than a marker for LBW (Almond et al. 2005; Doyle et al. 2003). Finally, methodologically, those studies regularly used multivariate regressions or logistic models with a categorical variable of race combinations. That is, having white/white parents as the reference group, assess the effects of being in the other three groups (white/black, black/white, and black/black), while controlling for a set of covariates. A potential concern regarding this approach is that it assumes covariates have the same effects (coefficients) on outcomes of interest across all racial combinations. This assumption may be flawed. As one example, some previous research has shown black infants may be disproportionately affected by maternal smoking during pregnancy, compared to white infants, for either biological (blacks are thought to have slower nicotine metabolism [NIH study]) or behavioral reasons (black women prefer high yield cigarettes [Peacock et al. 1990]). Careful testing of whether the covariates vary across groups is necessary to verify that estimates of the racial effect are not biased in analyses of biracial infants.

Purpose of this study

This study investigates the difference in outcomes (birth weight, LBW rate, Apgar score, infant mortality) for infants born to non-Hispanic white mothers and fathers of white (W-W, henceforth white and black refer to Non-Hispanic white and Non-Hispanic black), black (W-B), Mexican (W-M), Puerto Rican (W-PR), Central or South American (W-CSA), American Indian (W-AI), East Asian [10] (W-EA), and unknown (W-UN) race/ethnic background. Each of these eight groups is analyzed using the National Center for Health Statistics (NCHS) linked birth/infant death file for 2001. The analysis presented in this study utilizes a propensity scoring estimation approach, which compares outcomes of different groups by in effect matching the two groups' covariates.

DATA

The data used in this study come from the NCHS linked birth/infant death file for 2001. This 2001 birth cohort data consists of all 2001 live births and all 2001 and 2002 infant deaths linked to the corresponding 2001 birth certificates. 98.8% of all infant death records were successfully matched to their corresponding birth records. Based on birth certificates, this dataset has rich information on birth outcomes (birth weight, Apgar 5 score) and parents' demographic and socioeconomic background (race/ethnicity, age, maternal education). Excluded are fetal deaths which occurred prior to the complete expulsion or extraction from

[10] Chinese, Korean, and Japanese are combined into East Asian because each group has small number of observations, and these three groups are similar in terms of biological and cultural characteristics.

the mother of a product of human conception, irrespective of the duration of pregnancy, which are not an induced termination of pregnancy. This definition includes all cases of stillbirth, spontaneous abortion, and miscarriage (NCHS: Technical Appendix-Fetal Death 2001).

The dataset reports that in 2001 there were 4,031,635 live births, among which there were 23,762 infant deaths in the United States, excluding territories. Among the live births are 2,327,114 infants of white mothers, 590,105 of black mothers, and 615,683 of Hispanic mothers of Mexican origin. For each of these births, Table 6 summarizes the average birth weight in a variety of combinations of biracial births. The table shows that, generally, infants of black mothers have the lowest mean birth weight, compared to infants of white or Mexican mothers, regardless of paternal race/ethnicity. Among black mothers, B-B couples have one of the lowest mean birth weights, ahead of only Asian Indian and fathers those with unknown race/ethnicity. The missing paternal data group (next to last row in Table 6) shows a large disparity between infants of black mothers, where there is no data in 36.2% of cases, and white or Mexican mothers where paternal data is missing in 8.6% and 12.5% of births, respectively. One possible explanation for this inequality is the low marriage rate for black mothers (31.4%). It is noteworthy that, for each maternal race, when father's race/ethnicity is missing, infant mean birth weight is always lowest among all paternal groups. This implies that not considering this group or only using mother's race will yield a biased estimation of the racial/ethnic effect on birth outcome. For example, if white females with white male partners yield the highest birth weight, then any other paternal race/ethnicity will pull down the averages for all white mothers. That is, the birth outcomes of white parents are actually *underestimated,* and outcomes of "white infants" (a term may imply both parents are white) are therefore also *underestimated*, when using maternal race/ethnicity to refer to child's race/ethnicity.

Because this study's primary interest is on both maternal and paternal influence on birth outcomes, due to the high proportion of fathers whose race/ethnicity is missing for black and Mexican mothers, the analytic focus of this study is primarily on the singleton live births to *white* mothers, which is a common strategy used by some previous research (Solis et al. 2000). However, comparisons between white and black mother and their partners are briefly discussed at the end of results, as an extension of the primary focus). Eight paternal race/ethnicity categories were selected, each comprising at least 0.15% of the subpopulation of white mothers. Thus, infants born to white mothers and either Cuban or Asian Indian fathers were excluded, as there is not enough statistical power in those sub-samples.

Independent variables that are considered to be potential confounders that may vary across racial/ethnic groups include parental characteristics (age, maternal education, marital status, if mother was born in US), maternal behaviors (number of prenatal care visits, tobacco and alcohol use during pregnancy, weight gain during pregnancy, and adequacy of care), and child characteristics (live birth order and gender). Previous research has shown nonlinear effects of parental age on infant outcomes, so both maternal and paternal age were included and categorized in three groups: less than 20 years, between 20 and 34 years, and older than 34 years (Reichman et al. 2006). Maternal educational attainment has been shown to have a profound effect on both the number of births and the risk of adverse birth outcomes (Martin, et al. 2002). It is also categorized into three groups: less than high school (less than or equal to 9 schooling years), high school (between 9 and 12 years), and some college or beyond (more than 12 years). Since income is not available in vital statistics records, maternal education is frequently used as a proxy for socioeconomic status in this type of study (Hummer et al. 1999; Doyle et al. 2003). Children born to unmarried mothers have been found to have a higher LBW rate (Hessol et al. 1998), so an indicator of marital status is included in the analysis. Adequacy of prenatal care was coded to include the month prenatal care began, the number of prenatal visits, and the gestation period (NCHS codebook). The child characteristics are included because female infants on average are smaller than male infants, and previous research has shown that first-born children have a higher risk of LBW (Miller 1994).

Outcomes of interest include birth weight, LBW rate, Apgar score, and infant mortality (within the first year after birth). All of these outcomes are simply used as reported in the NCHS dataset.

METHOD: PROPENSITY SCORING

In this study I use propensity score analysis, which is a transparent analytical tool for adjusting for confounding factors (Rosenbaum and Rubin 1983) across groups. The propensity scores were estimated by using a nonparametric regression technique that minimizes imbalance in the covariate distributions between the groups as much as is possible. This technique is the generalized boosted model (GBM, Ridgeway 2005), "a general, multivariate, data adaptive modeling algorithm that can estimate the nonlinear relationship between a variable of interest and a large number of covariates of mixed type (binary, ordinal, continuous), while also allowing for flexible, non-linear relationships between the covariates and the propensity score" (Ridgeway 2006). In this way, the weighted joint distribution of each comparison group's features will be identical to the joint distribution of the reference group demographic and socioeconomic characteristics.

In this particular analysis, infants born from white mothers and black fathers (W-B) are the reference group, because blacks have long been the focus of health disparity, and all other combinations are comparison groups that are individually weighted to match the reference. For instance, W-W infants are one of the comparison groups. Those W-W infants with similar background features as W-B infants are most like those in the reference group; therefore, they receive higher propensity scores and also higher weights. Conversely, those W-W infants who have very dissimilar characteristics from W-B ones will have p_i near 0, and thus they get nearly zero propensity score weights. In this way, we in effect examine what would be the birth outcomes of infants born to white mothers and white fathers if they had exactly the same demographic (e.g. gender) and socioeconomic characteristics (e.g. maternal education) as those born to white mothers and black fathers. In anther word, the differences in birth outcomes between groups (e.g. W-W and W-B), when all the observed variables are made to be the same by weighting, can be attributed to paternal race/ethnicity, assuming that I have already captured most important covariates.

After constructing and applying the propensity score weights with the GBM algorithm, as described above, the only observed differences between the comparison group and the reference group should be race and any outcomes that differ significantly by race. All covariates now have similar distributions in both groups, as a result of the propensity score weighting, so the difference in the average outcome between the two groups, which can be attributed to race, is the "race effect", assuming that we have captured all the important risk factors.

RESULTS

2,212,425 births in 2001were available for analysis after restricting the data to singleton infants born to white mothers (and fathers from one of the eight included races and ethnicities), including the category of missing information. Table 7 presents a summary of parental and child characteristics obtained from birth certificates, by paternal categories. Those characteristics greatly differentiate paternal groups: in general, the group with missing father information is unique, and shows maternal characteristics that are the most disadvantaged among all groups: 28.3% of the mothers were less than 20 years old, 11.3% had less than a high school education, (probably a correlation with young maternal age), and only 7.3% were married. Those mothers also tend to have much riskier behaviors during pregnancy: the probability of tobacco (61.3%) and alcohol (2.0%) use during pregnancy were much greater than in any other group. This observation is consistent with the lowest average birth weight in each maternal race/ethnicity group, as reported in Table 6.

Among available paternal race/ethnic groups, characteristics for whites (W-W) and East Asians (W-EA) are quite similar in many ways. Compared to other racial/ethnic groups they both tend to have children late (especially within W-EA group): only 6% and 3%

mothers, and 2.5% and 0.9% fathers were younger than 20, within W-W and W-EA groups, respectively. These two groups also had higher percentages of college education (62% and 79% respectively), marital rates (both over 85%), and proportions receiving adequate prenatal care (both over 80%). The groups of W-W and W-EA also had lower prevalence of tobacco use (13% and 6%) during pregnancy.[11]

Among other paternal groups, black (W-B) and American Indian (W-AI) are both found to have several disadvantaged maternal characteristics: W-B had the lowest marital rate of 45%; both black and American Indian male's white female partners had very high prevalence of tobacco use, 23% and 25%, respectively. Furthermore, American Indian male's female white partners tended to smoke more cigarettes and had more drinks every day when they did smoke or drink, compared to other groups.

Among Hispanic fathers, Mexican and Puerto Rican's white partners are found to be similar in parental characteristics except for tobacco and alcohol use. Female partners of Puerto Rican men (W-PR) had higher prevalence of using tobacco (20%) and using alcohol (1.3%), compared to those of Mexicans (W-M), 16% and 0.8% correspondingly. Note there is a high proportion of missing data on W-M's tobacco and alcohol use, since many of them resided in California. However, unless W-M mothers in California have a disproportionately higher rate of smoking or drinking compared to their counterparts in the rest of the country,

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[11] California doesn't report maternal tobacco and alcohol use on its birth certificate and nearly a third of total East Asians reside in California nationwide. Therefore, a very high proportion of W-EA (34%) have missing values for tobacco/alcohol use. For the same reason, Mexicans (W-M) also have very high proportion (28%) of missing values.

which is unlikely given that California has one of the strictest anti-smoking policies and California actually has the second lowest smoking rate among women (CDC 2003) of any state in the U.S., their prevalence of tobacco and alcohol use during pregnancy will still be much lower than that of W-PR. Another perceptible difference between these two groups is that W-M had a higher percentage married (66%) than W-PR (55%). Central or South American men's white female partners (W-CSA), on the other hand, had relatively better maternal characteristics, compared to W-M and W-PR: less than 10% W-CSA gave birth before 20, more than half had some college or beyond education, 75% were married, and they also had relatively low rates of tobacco and alcohol use during pregnancy. These results are evidence that white female partners of Mexican, Puerto Rican, and Central or South American men are different in many ways, which probably reflects differences within Hispanic male partners of different origins; therefore Mexican, Puerto Rican, and Central or South American should not be simply grouped and labeled as Hispanics as a whole for study. This is consistent with other health studies.

Since California birth certificates do not report on tobacco or alcohol use during pregnancy, and tobacco and alcohol use are important behavioral risk factors, California data are excluded from subsequent analyses. Table 8, in the same fashion as Table 7, presents the distribution of covariates as well as infant outcomes, across selected racial and ethnic groups of all states but California. The patterns of covariates across racial and ethnic groups are similar to those in Table 7 where California was included. For example, examining birth outcomes, W-W has the highest average birth weight, the lowest LBW rate, the second lowest infant mortality rate, and the highest 5-minute Apgar score, as expected from Table 7. In contrast, W-UN has the worst birth outcomes in each category. W-B, although possessing slightly higher average birth weight than W-M and W-PR, not surprisingly has a higher LBW rate and infant mortality rate than any other group except for W-UN. The differences between W-W and W-B can be seen in the mean birth weight gap of 70 grams, the LBW rate gap of 1.62%, the infant mortality rate gap of 2.78 per thousand, and the 5-minute Apgar score difference of 0.024.

After applying weights derived from the propensity scores to the comparison groups (W-W, W-M, W-AI, W-PR, W-CSA, and W-UN), the weighted joint distribution of covariates of each comparison group should be identical to the joint distribution of the reference group W-B's covariates. One finding is when calculating a propensity score for each comparison group to match with the reference group, the marriage rate was always the most relative influential variable,[12] which means the biggest difference in covariates between the reference group, W-B, and other groups, is the marriage rate. Table 9 presents the statistics of covariates for each weighted comparison group, after calculating propensity scores for each and applying the appropriate weights, and shows that each comparison group's features are now very close to those of the reference W-B group. W-B remains the same in Table 9 as in Table 8 because W-B is the reference group. For instance, now each racial and ethnic group's martial rate is around 45%, 14% of the mothers are under 20 years old, 39% have some college or

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[12] "Relative influence" of each covariate is determined by decomposing the overall improvement in the model's log likelihood into the portion attributable to each covariate (McCaffrey et al. 2004).

beyond education, and about 22% used tobacco during pregnancy. This will infer what would be birth outcomes for non-W-B groups who had exactly the same covariates as W-B, and the differences in birth outcomes between these hypothetical outcomes of non-W-B and W-B's outcomes can be attributed to the effect of being W-B.

Table 9 also presents infant outcomes for W-B and weighted outcomes for the comparison groups: when every comparison group's covariates are distributed in the same manner as W-B, the average birth weight decreases and both LBW rate (except for W-AI) and infant mortality rate increases, for every comparison group but W-UN. Now the difference between W-B and weighted W-W is only 7 grams and the difference in LBW rate is only 0.19%, though the differences are still statistically significant because of the large sample size. The changes in birth outcomes of W-UN are just the opposite. For the W-UN, when matched with W-B by covariates, although birth outcomes of weighted W-UN are still worse than other groups, the average birth weight of W-UN is increased by 65 grams, from 3,250 to 3,316 grams, the LBW rate decreases from 8.39% to 6.85%, the infant mortality rate declines from 10.23 to 7.81 per thousand, and Apgar score increases from 8.88 to 8.90. In other words, most comparison groups' advantaged birth outcomes shrink when their covariates are "matched down" against those of W-B, and the W-UN's disadvantaged birth outcomes are improved when W-UN's covariates are "matched up" against those of W-B. These results show that when every racial and ethnic group has the same distribution of observed covariates as W-B, the disparities in outcomes across groups are largely explained. That is, the paternal race *per se* plays a very small role in birth outcome disparities, net of measured covariates.

DISCUSSION/CONCLUSIONS

This study used a nonparametric approach, propensity score estimation, to examine differences in 2001 year infants born to white mothers and fathers from several different racial/ethnic backgrounds. In general, we find that within the group of white mothers there is substantial variation in infant outcomes across paternal racial and ethnic groups. Specifically, W-W has the most advantaged birth outcomes, followed by the three Hispanic father groups of W-M, W-PR, and W-CSA. W-AI has high average birth weight but also relatively high infant mortality rate. W-B has the second most disadvantaged birth outcomes: the differences in birth outcomes between W-B and W-W are 70 grams in average birth weight, 1.62% in the LBW rate, and 2.78 per thousand in the rate of infant mortality. W-UN has the most disadvantaged outcomes in each category. These heterogeneities within white mothers show that the common practice of using maternal race and ethnicity to refer to race and ethnicity of the infant is problematic: W-W have the best birth outcomes among the groups studied, so any other paternal race/ethnicity pulls down the averages for all white mothers. That is, the birth outcomes of W-W are actually *underestimated* and thus the racial and ethnic disparities between white and any other race or ethnicity may be *underestimated* accordingly as well.

This issue has already been recognized as a potential source of problems. For example, in 1997, in order to reflect "the increasing diversity of our Nation's population, stemming from growth in interracial marriages and immigration", the Federal Office of Management and Budget (OMB) revised the standards for how the Federal government would collect and present data on race and ethnicity: for example, Census 2000 includes as many as 63 possible combinations of race (OMB report). Despite this effort, using maternal race/ethnicity to refer to child's race/ethnicity is quite common in most research and many data collection efforts, such as NCHS and research using data from the NCHS, because "the National Vital Statistics System, which is based on data collected by the states, will not be fully compliant with the new standards until all of the States revise their birth certificates to reflect the new standards…Once all states revise their birth registration systems to be compliant with the 1997 OMB standards, the use of bridged populations can be discontinued." (NCHS 2004) This approach, as discussed above, yields underestimated outcomes for W-W or white infants, disguises disadvantaged outcomes of W-UN, and may lead to biased comparisons between white and non-white infants. Therefore, before the 1997 OMB standards are widely implemented and accepted, researchers need to be clear and cautious when using maternal race/ethnicity to refer to child's race/ethnicity.

We also observe differences in parental and child characteristics across subgroups of white mothers with partners of different races and ethnicities. That is, white women who had white husbands or partners are different in many ways from those white women who had non-white husbands or partners. On the whole, W-W has the most advantaged parental and child characteristics: W-W has the highest percentage of married parents, lowest percentage of either mothers or fathers younger than 20, higher levels of formal education completed, and relatively lower tobacco and alcohol use. In contrast, W-B and W-UN have the most disadvantage parental characteristics. These patterns, where white women with white partners have more advantaged characteristics than those of white women with non-white partners, are consistent with previous studies of intermarriage in US, such as Fu (2001)'s study discussed previously. Since we don't have SES information of fathers in our data, we cannot test the status exchange hypothesis (i.e. we don't know if white male partners of white women are socio-economically better off than non-white partners of white women), but this data analysis is consistent with the in-group preference hypothesis because, for example, within the white mother group, white women and white men have a relatively high marital rate, especially among those with higher SES.

Using propensity scores to weight the covariates of each comparison group (W-W, W-M, W-AI, W-PR, W-CSA, and W-UN) to match the reference group (W-B), we virtually created samples of infants from each comparison group with backgrounds similar to observed W-B infants. By design, the only observed attributes that should differ between the two groups (W-B and each comparison group), are race and birth outcomes. The birth outcomes of each weighted comparison group are very close to those of W-B: weighting reduces the difference in birth weight between W-B and W-W from 70 to 7 grams; weighting increases LBW rate of W-W from 4.64% to 6.07%, which is much closer to W-B's 6.26%; and W-W's infant mortality rate of 4.29 per thousand is also increased to 6.44 per thousand, closer to W-B's 7.07 per thousand. The same patterns are observed for every other comparison group but W-UN. Because W-UN's covariates are disadvantaged compared to W-B, when matching with W-B, birth outcomes of the weighted W-UN get much better, although are still statistically different from those of other groups. Thus, when comparing weighted groups to W-B, only very small differences in outcomes remain across groups that may be attributed to paternal race and ethnicity or omitted variables such as income. These results show that the disparities in birth outcomes among subgroups of white mothers can be largely attributed to non-racial parental characteristics. Results also show the covariate that has the most relative influence is marriage rate. Therefore, father's race, to some degree, is a proxy for SES or behavioral factors associated with marital status.

The small paternal racial effect on birth outcomes found by this study is a result, in large part, of the fact that mothers play a more important role than fathers in the course of pregnancy and therefore mother's race and ethnicity has more influence on infant outcomes. In other words, should we compare white mother-black father to black mother-black father, we would likely find a big maternal racial effect. However, as discussed earlier, black and Mexican mothers in the NCHS dataset partner with a very high fraction of unreported fathers. In particular, not knowing any information about more than one third of the partners to the black mothers, any attempt to compare the remaining black mothers will risk enormous bias. Nevertheless, just to offer a rough sense the possible difference between maternal and paternal race/ethnicity influence, I used infants of B-B (black mother-black father) as a reference group and compared that to those of B-W (black mother-white father) and W-B (white mother-black father), where the former comparison assesses the paternal effect given black mother, and the latter comparison estimates the maternal effect given black father. As table 10 shows, the estimated maternal effect is more than three times as large as the paternal effect in terms of birth weight, LBW rate and Apgar scores, and almost that large for infant mortality rate.

However, due to the high rate of unreported fathers for black mothers, this is a rough assessment and not meant to be conclusive.

As discussed previously, W-UN is a category of its own. Within this group, only 7% of mothers were married, almost 30% were less than 20 years old, as many as 39% smoked and 2% used alcohol during pregnancy, 10% received inadequate prenatal care, and 53% of infants were first births. Not surprisingly we find that this group's outcomes are the most disadvantaged: infant mortality is twice that of most groups and about 1.5 times that of W-B and W-AI. However, after applying the propensity-score weighting to match W-UN to W-B, which increases the marital rate, as well as other covariates of weighted W-UN, to the same level of W-B, the outcomes of W-UN still remain significantly disadvantaged against other groups. That is, a W-UN group with the same maternal and child features as W-B would still have worse outcomes. Clearly, the unreported father is a good proxy for more noteworthy factors.[13] This confirms findings by Gould and his colleagues, who argue that incomplete birth certificates provide an important marker for identifying high risk women and vulnerable infants. They also pointed out data "cleaning" in analysis might result in the removal of those mothers and infants at risk (Gould et al. 2002). In this study, we find that unreported fathers are perhaps the most vital marker for identifying infants at risk.

Although the exact pathways of how unreported fathers would affect infant health at birth are not definite, one possibility is that infants in this group are "unintended" births and

[13] Further research is needed to investigate the reasons why father's information is missing on so man y birth certificates. In particular, we want to distinguish fathers just missing on birth certificates for some reason from those completely missing from the child's life.

they are likely to receive less care than "intended" infants, both during pregnancy and after birth. In this case, "unintended" means pregnancies that are either entirely unwanted or mistimed (sooner than desired) at the time of conception.[14] The 1995 National Survey of Family Growth was the first national survey that asked women about their feelings towards their pregnancy. The survey found that up to 31% of all births had not been intended, including 22% mistimed and 9% unwanted births, meaning that the respondent indicated that she had not wanted to become pregnant then or ever (Abma et al. 1997: Table 14). Contrary to the common impression of teenage pregnancy, most of those unintended or unwanted pregnancies occur among adults, rather than adolescents (Hogue and Vasquez 2002).

Unintended pregnancy can carry serious consequences at all ages and life stages. "Best intentions: unintended pregnancy and the well-being of children and families" (1995) identified several pathways: first, unintendedness itself poses an added and independent burden beyond typical risk factors such as the social and economic attributes of the mother in particular. Furthermore, women bearing children who were unintended at conception are more likely to be at higher medical and social risks. Finally, lack of intent or planning often precludes individual women and couples from participating in preconception risk identification and management. Fuchs (1998) even argued that one of the reasons for the

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[14] It is important to note that there is no clear line between "intended" and "unintended" pregnancy, especially in the situations where partners don't agree with each other. It can be further complicated by recall bias because most surveys are done months or years after the pregnancy.

marked decline in infant mortality since 1965 was a substantial decrease in "unwanted" births after 1965 as a result of improved contraception and more liberal abortion laws (Fuchs 1998).

In conclusion, this study has multi-dimensional implications for public health: first, counter to the common conception that white mothers are at lower risk for poor infant health, this study finds that there are great variations within the white mother group, especially in education and behaviors. This implies that prenatal interventions need to pay more attention to the disadvantaged mothers within all racial and ethnic groups, even when the particular race/ethnicity is normally not considered at risk. As Hogue and his colleague argued, the increased infant mortality rate in recent years might be a result of the segregation of priorities that occurred early in the 1990s, when national concern was diverted from infant mortality to minority health. They concluded that it is time for health policy makers to prioritize integration of the concerns of all pregnant women, not just minorities (Hogue and Vasquez 2002).

Secondly, the mother's partner deserves more attention. Not only can the father's characteristics (for instance, father is unknown) help to identify potential risks, but his behaviors affect the mother's behaviors. For example, some previous research has shown that, regardless of marital status, a woman's substance use during pregnancy is highly correlated with both her partner's substance use and the degree of emotional support he provided (Perreira & Cortes 2006). Unfortunately, limited information in the data set means that such an analysis is beyond the scope of this study.

Finally, further research is needed to assess to what extent "unintended" or "unwanted" births can explain disadvantaged infant health. In parallel with further research efforts, policies and programs need to be carefully designed to address how to improve the unwanted infant's health. One possible intervention conceived with this unwanted pregnancy concern in mind is for doctors or social workers to help facilitate the mother's access to prenatal and postnatal care, better nutrition, and behavior counseling. A long-term policy, perhaps, should focus on prevention of such pregnancies; as "Best Intentions" (Brown and Eisenberg 1995) concluded, a national campaign is needed to adopt a new national social norm: All pregnancies should be intended--that is, they should be consciously and clearly desired at the time of conception. This campaign should include both specific goals such as improving knowledge about contraception and reproductive health, and increasing access to contraception, and general strategies of educating the public about the major social and public health burdens of unintended pregnancy.

CHAPTER 4 -- Associations between birth outcome measures and infant mortality at different time periods

INTRODUCTION

The infant mortality rate, reported as the number of live newborns dying in the first year after birth per one thousand live births, is a common indicator of health and social development. Despite the fact that the United States experienced a 95% to 99% reduction in infant mortality during the twentieth century (Hoekelman and Pless: 1988)[15], large disparities in infant mortality rates among racial and ethnic groups still persist; since 1971 the mortality rate disparity between black and white infants has remained unchanged or increased (Mathews et al. 2003; MMWR 2002). In 2003, infant mortality rates were highest for infants of non-Hispanic black (13.6 deaths per 1,000 live births), American Indian (8.7 per 1,000), and Puerto Rican mothers (8.2 per 1,000); and lowest for infants of Cuban (4.6 per 1,000), Asian or Pacific Islander (4.8 per 1,000), and Central or South American mothers (5.0 per 1000). Infants of Non-Hispanic white mothers had an infant mortality rate of 5.7 per 1000 (NCHS: Health 2006, Table 19). It is important to note these substantial differences in infant mortality by race and ethnicity, because prevention efforts can best be directed to both specific target populations and particular risks for infant death (Rogers 1989).

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[15] However, in 2002, the infant mortality rate increased for the first time in more than 40 years (NCHS: Health 2006).

Furthermore, when taking a closer look at infant deaths, the racial and ethnic differences in neonatal deaths (death during the first 27 days of life) are higher than those in postneonatal deaths (death between 28 and 364 days of life). For instance, the 2003 non-Hispanic black neonatal mortality rate was 2.45 times greater than non-Hispanic whites, while their postneonatal mortality rate was 2.26 times that of whites.[16] However, Hessol and her colleague found that after adjusting for maternal and infant characteristics there were no significant ethnic differences in neonatal mortality, while racial/ethnic differences in postneonatal mortality remain, based on California linked birth-infant death certificates from 1995 to 1997 (Hessol & Fuentes-Afflick 2005). Kempe and colleagues (1997) studied postneonatal deaths in four regions selected to represent the US. They found, after accounting for maternal characteristics, that infants born to black mothers had a significantly higher postneonatal death rate than those born to white mothers (7.3 vs. 3.0 per 1000).

These data show that causes of and risk factors for infant mortality may differ both by maternal ethnicity and by time since birth. Consequently, this study intends to both investigate whether and how racial/ethnic disparities in mortality change over the course of the first year after birth, and compare the associations between a set of birth outcomes (such as birth weight, gestational age) and infant mortality at different periods (early neonatal [first 7 days since birth], late neonatal [between 8 and 27 days], and postneonatal [between 28 and 365 days]).

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[16] In 2003, the neonatal mortality rate was 9.3 per 1000 for non-Hispanic blacks, 3.8 per 1000 for Non-Hispanic whites; the postneonatal mortality rate was 4.3 per 1000 for blacks and 1.9 per 1000 for whites (NCHS, Health 2006: Table 19).

LBW, prematurity, and low Apgar score are associated with risk of mortality

Previous research demonstrates that the infant mortality rate is highly sensitive to birth weight: in general, the infant mortality rate declines as birth weight increases.[17] Low birth weight (those infants who weigh less than 2,500 grams) infants at term have a perinatal mortality (the sum of stillbirths plus early neonatal deaths) rate that is five to 30 times greater than that of infants whose birth weights are at the 50th percentile. The mortality rate is 70 to 100 times higher in those very low birth weight (VLBW) infants who weigh less than 1,500 grams than those who are of normal weights (Cunningham FG, et al 1997). Recent studies (Callaghan et al. 2006; Sowards 1999) argued that gestational disorders lead to infant death via numerous pathways, therefore it is not always clear how to assign the causes of death. Together they found that the International Classification of Diseases (ICD) codes, used by agents like National Center for Health Statistics (NCHS), to classify causes of death underreported prematurity (less than 37 weeks of gestation) and LBW as the underlying cause of death. When short gestation/LBW is listed in conjunction with a more-specific cause of death, then typically the specific cause is selected and reported on the certificate. For example, infant deaths attributable to respiratory distress syndrome, a result from incomplete lung maturation in preterm infants, are always counted in the category of respiratory distress instead of preterm/LBW. Callaghan and his colleagues reexamined the 20 leading causes and

[17] Though it doesn't mean that heavier is unequivocally better. Very heavy newborns (i.e. more than 9.5 pounds), usually resulting from gestational diabetes, also face an increased mortality rate. The "optimal" birth weight, in terms of the lowest mortality rate, is about 9.5 pounds. The benefit of an increase in birth weight is relatively large when below LBW (5.5 pounds), and diminishes as birth weight increases, until it is no longer beneficial.

they found preterm (both LBW and prematurity) is the most frequent cause of infant death in the U.S., accounting for at least one third of infant deaths in 2002 (Callaghan et al. 2006).

In 1952, Dr. Virginia Apgar developed a scoring system to evaluate the condition of neonates born at Sloane Hospital for Women in New York City. Each component of the Apgar scoring system is based on signs traditionally used by anesthesiologists to monitor a patient's condition during surgery (Papile 2001). About ten years after the initial publication, the acronym APGAR was introduced in 1963 by the pediatrician Dr. Joseph Butterfield in the U.S. as a mnemonic learning aid: Appearance (skin color), Pulse (heart rate), Grimace (reflex irritability), Activity (muscle tone), and Respiration. The score directly measures five easily identifiable infant characteristics—heart rate, respiratory effort, muscle tone, reflex irritability, and color, on a scale of 0,1 or 2, with 2 representing optimum behavior for each sign (CDC 2002). The Apgar score is the sum of the scores of the five components, and a value in the range of 7-10 (high) is regarded as good to excellent, 4-6 (medium) is moderately low, and 0-3 (low) is considered severely low. A score under seven typically indicates an infant's need for medical intervention such as cardiopulmonary resuscitation (CPR), artificial respiration, catheterization, oxygen therapy, and careful observation (Weinberger et al. 2000; Doyle et al. 2003). The 5-minute Apgar score, performed by doctors five minutes after delivery, has been continuously found to be a very powerful predictor for infant mortality (Casey et al. 2001; Weinberger et al. 2000; Papile 2001; Doyle et al. 2003; Almond et al. 2005). Doyle and colleagues (2003) concluded that "Apgar scores are strong predictors of infant survival, independent of birth weight, gestational age, and a large number of maternal risk factors." In addition, Casey and colleagues found that the Apgar scores, as predictor of neonatal survival, remained as relevant as almost 50 years ago (Casey et al. 2001).

Why these measures (LBW, birth weight, gestational age, Apgar score) can be problematic

In most research, LBW has been used as a dichotomous variable, namely, low *versus* normal birth weight, leaving the distribution of actual birth weight overlooked. The current cutoff point of 2,500 grams was derived from studies of Caucasians in early 1900s, and was originally chosen in 1919 by a Finnish pediatrician named Arvo Ylppö, as a means to differentiate preterm from term infants (Kiely et al. CDC). This definition was accepted by the American Academy of Pediatrics in 1935 and the World Health Organization (WHO) in 1948 as a universal definition of LBW, although the latter made a distinction between "immature" as indicated by birth weight and "premature" as measured in a gestational age of less than 37 weeks (McCormick 2006).

Since the 1980s, the US percentage of LBW infants has been steadily increasing, in part as a result of the rising rate of multiple births. The rapid rise in multiple births accounted for 2.3% and 3.1% of all live births in 1990 and 2000, respectively; triplets and higher-order multiples accounted for an increasing proportion of multiple births (3.1% and 5.8%, respectively), an estimated 53% of which were the result of assisted reproductive technologies (Luke and Brown, 2006). At the same time, infant mortality rates have declined steadily (DHHS, 2004). This may imply that the threshold of LBW should be lower. Furthermore, baby size at birth varies considerably across countries, races, and genders. At the extreme, mean infant birth weight was 3,500 grams in Sweden but only 2,900 grams in India (Paneth 1995). It has been well documented that female infants have lower average birth weight than males in each racial/ethnic group, but they also tend to have better health status than boys (Almond et al. 2002). A similar case, the so-called "LBW paradox", also occurs to Mexican-American babies who tend to have lower birth weights compared to their white US born counterparts but still enjoy better overall survival rates (Paneth 1995, Wilcox 2001). Anther interesting example is that, when comparing infants of the U.S. as a whole and those of Colorado in particular, high altitude is found to produce more LBW babies, but this does not lead to an increase in infant deaths (Wilcox 2001). Each of these observations suggests that it may not be appropriate to universally apply the current LBW threshold to every sex- and race/ethnicity-specific population.

The practice of using birth weight as a continuous variable has been challenged as well: This approach assumes that every gram increase has the same effect on outcome, which is fallible because birth weight effect varies according to the position of the distribution of birth weight. Wilcox suggested that there should be a distinction between the predominant and residual distribution of birth weight, and the latter distribution, which was defined as a difference in the rate of small preterm births, was more important (Wilcox 1986; 2001).

In the 1950s and 1960s, epidemiologists and perinatal clinicians began to recognize that LBW is determined by two processes: duration of gestation and rate of fetal growth (Kramer 1987; Kiely et al. CDC). Thus, infants can have LBW either because they are born early (preterm birth) or are born small for gestational age (SGA), a proxy for intrauterine growth retardation (IUGR).[18] Correspondingly, public health and medical researchers have suggested the utility of classifying births according to combinations of birth weight and gestational age as a means of evaluating infant mortality risk (Frisbie et al. 1996). However, this approach is in question because some SGA infants are merely small rather than nutritionally growth restricted; conversely, some IUGR infants who would otherwise be constitutionally large do not meet the standard criteria for SGA. Moreover, newborn infants may be growth-restricted or preterm without having LBW (Kramer 2003). As Paneth writes,

> "A baby is small at birth either because it was born too soon, because it grew too slowly in utero, or because of some combination of the two. Preterm delivery and fetal growth appear to have distinct determinants, and one of the most important and little-appreciated observations about the state of our knowledge in this area is that, while we have considerable understanding of the causes of impaired fetal growth, we know next to nothing about preterm delivery" (1995, p. 25).

Although birth weight or LBW cutoff, as discussed above, has many theoretical and empirical shortcomings as measures for pregnancy outcome, and although the WHO officially pronounced that low birth weight was no longer synonymous with prematurity (Wilcox 2001), it is still widely reported and studied by epidemiologists and public health practitioners, because of one practical advantage: it can be measured easily and precisely. In contrast, measuring gestational age or IUGR is much less accurate or direct, especially when

[18] WHO defines preterm birth as delivery before 37 completed weeks of gestation and SGA as a birth weight below the 10th percentile for gestational age (above the 10th percentile are called adequate for gestational age or AGA).

pre-ultrasound is not conveniently available. Gjessing and colleagues (1999) stated that errors in gestational age are inevitable with nearly any method of measurement, including the commonly used benchmark of the last menstrual period. Using birth registration data from Norway, they found some gestational age could be misclassified with four weeks shorter or longer.

The Apgar score, on the other hand, despite well-documented predictive power of infant mortality, can be controversial as well. Studies have found that Apgar scores are significantly higher for white infants than for black infants (Petrikovsky et al. 1990; Heygi et al. 1998), and Yama and colleague argued that lower Apgar scores for blacks might be due to the “color” component, because it is hard for black infants to appear “pink” (Yama & Marx 1991; Doyle 2003).

Purpose of this study

Having realized the problems of treating birth weight as either a dichotomized or continuous variable, a number of recent studies have made a concerted effort to suggest alternative approaches of either exploiting different forms of birth weight or using a combination of birth weight and gestational age or other information, as a means of evaluating infant mortality risk and other health outcomes. Nevertheless, there is yet to be a systematic review of those individual efforts. As one step towards this goal, this study first reviews already proposed alternative techniques of treating birth weight in analysis as well as their findings and constraints. Second, this study selects a group of alternative strategies that are applicable to vital statistics and survey data, and then compares their predictive power for infant mortality (including perinatal, neonatal, and postneonatal mortality), using National Center for Health Statistics (NCHS) linked birth/infant death file for 2001.

Review: proposed alternative approaches of how to use birth weight

Researchers have made a great effort to explore a number of plausible means of utilizing different forms of birth weight, or/and by combining weight, length, gestational period, and other information since the 1980s. Those already proposed alternatives can be sorted into the following categories: birth weight only, combining birth weight with other body measures at birth, combining birth weight with gestational age, and when Apgar scores are available:

1. Combining birth weight and body measures at birth: Examples include Rohrer's ponderal index, which takes weight as a ratio to length cubed (Haas et al. 1987), similar to the better-known body mass index (BMI). Studies suggest that adulthood obesity, type 2 diabetes, and death from coronary heart disease are all associated with a low ponderal index at birth, sometimes whose associations are found to be even stronger than those between health outcomes and birth weight (Forsen et al. 2000; Eriksson et al. 2001; Barker et al. 2002). Head circumference is another often recommended measurement. For example, large head circumference at birth (35 cm or greater) is associated with higher risk of brain cancer in children (Samuelsen et al. 2006). When measurements of newborns' length or head circumference are available, a common clinical practice is to classify infants with IUGR as either *disproportionally/ asymmetrically* growth-retarded infants who have relatively normal length and head circumference for gestational age but LBW (i.e. they are thin) or

proportionally growth-retarded infants who have symmetric reductions in weight, length, and head circumference (i.e. they are small but normally proportional for size) (Kiely et al. CDC). However, this type of information is often only available on individual hospital records. Only two states—Missouri and Wisconsin—record crown-heel length and head circumference on the birth certificate (Kiely et al. CDC).

2. <u>When only birth weight is available:</u> Sometimes, and especially in many developing countries, birth weight is the only feasible and reliable measure at birth. Therefore, scholars have explored different ways of using birth weight as the lone predictor of infant mortality and other outcomes.

2.1 <u>Different forms/models of birth weight:</u> Quantile regression is one of the models that have been introduced. Quantile regression provides a method for estimating models of conditional quantile functions, where the median (the 50th percentile), or some other quantile (such as the 10th or 90th percentile), is expressed as a function of observed covariates. It provides information on how covariates are related to birth weight at different points of the distribution. Abrevaya (2001) used quantile regression on large subsamples of singleton births from the 1992 and 1996 Natality Data Sets to study the effects on birth weight of background demographic and social characteristics and maternal behaviors. He estimated a set of five models (for the following quantiles: 0.10, 0.25, 0.50, 0.75, and 0.90) and the results show that linear regression models clearly underestimate covariate effects at lower quantiles for several important variables (Abrevaya 2001). Koenker and Hallock extended Abrevaya's work as an illustrative analysis in an article providing an introduction to the technique of quantile regression. They estimated a total of 19 models, for the 0.05 to the 0.95 quantiles (Koenker and Hallock 2001).

2.2 Residual distribution of birth weight (Wilcox): Wilcox argued,

"As a general statement, birth weight is not important in the analysis of infant. In contrast, preterm delivery is on the causal pathway to infant mortality. However, gestational age data are often incomplete or of poor quality, which can make it difficult to identity preterm births. (Therefore) when birth weight is the only type of data at hand, the percent of births in the residual distribution is preferable to LBW as an indicator of perinatal health" (Wilcox 2001, p.19).

Wilcox hypothesized that birth weight distribution consists of two components: a "predominant" distribution and a "residual" distribution. The predominant distribution comprises the vast majority of births in the bell-shaped curve, which corresponds closely to the birth weight distribution of term births (at least 37 weeks); the residual distribution is about 2 to 5% of births that are in the long lower tail of the curve that falls outside of predominant birth weight distribution. [19] Virtually all births in the residual distribution are preterm, but not all preterm births are in the residual distribution—just the small ones. Thus, distinguishing these two distributions of birth weight provides indirect information on gestational age without actually requiring gestational age data. Wilcox and his colleagues have developed an online program to estimate the residual distribution, which can help identify the percent of small, high-risk preterm births in any study population. [20] The basic idea is to group infants

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[19] Umbach (1996) found that the residual distribution in the upper tail has little impact on infant mortality (Wilcox 2001).

[20] The program is available at: http://eb.niehs.nih.gov/bwt/asp/prog1.asp

into 100-gram categories and then adjust all birth weights to a z-score scale, which is based on the underlying Gaussian distribution of births in each group being compared. So birth weight is used as a relative rather than an absolute measure. The online program was developed to assess parameters in the presence of excess small births (Wilcox and Skjoerven 1992).

3. Combining birth weight and gestational age: A major advance in the measurement of prematurity occurred when researchers noticed that birth weight and gestation are far from perfectly correlated and thus both pieces of data are useful and they offer different information in assessing newborn outcomes (Kiely et al. CDC). As discussed previously, LBW infants consist of two major groups: preterm and IUGR, which have fundamentally different causes, and therefore, different consequences. In order to distinguish these two causes, several thresholds and combinations of birth weight and gestation age have been proposed:

3.1 Basic combinations of birth weight and gestational age: Several ways of combining birth weight and gestational age have been proposed. A basic version is depicted in Figure 1, using thresholds of 2500-gram birth weight and 37-week duration of gestation for classification purposes: preterm large-for-gestational age (<37 weeks but >=2500 grams), term normal birth weight (>=37 weeks and >=2500 grams), preterm LBW (<37 weeks and <2500 grams), and IUGR (>=37 weeks and <2500 grams) (CDC 1994). A modified version could be normal birth outcome (>=2500 grams), LBW associated with IUGR (>=37 weeks and <2500 grams), and LBW associated with prematurity (<37 weeks and <2500 grams) (Hummer 1999).

3.2 Using fetal growth rate (FGR) to identify IUGR births: The FGR, defined as "the ratio of the observed birth weight at a given gestational age to the mean birth weight for gestational age of a sex specific fetal growth distribution" (Kramer 1987), is proposed to be used as proxy for IUGR births: births that have less than 0.85 FGR are identified as IUGR infants. As Frisbie and his colleagues have demonstrated, the use of ratios of birth weights to the gestation-specific mean is not the same as using percentiles of the birth weight distribution by gestational age (Frisbie et al. 1996). Frisbie and his colleagues developed an eight-category scheme that takes into account the infant's birth weight, gestational age, and maturity (calculated as FGR). Each of the three components is dichotomized and then cross-classified to produce an eight-category scheme (Frisbie et al. 1996). Hummer and his colleagues further revised this scheme to six-categories because two categories (>=37 weeks, FGR>=.85, <2,500 grams) and (<37 weeks, FGR<.85, >=2,500 grams) are found to be very rarely populated, if at all (Hummer et al. 1999).

3.3 "Optimal combination of birth weight and gestational age" (Solis et al. 2000): Based on the z-score adjustment technique developed by Wilcox and others, Solis and his colleagues proposed an alternative measurement strategy that relied on continuous measures of birth outcomes, identified an optimal combination of birth weight and gestational age for infant mortality, and estimated the effects of adverse birth outcomes in terms of their departure from this optimal point. This approach has a great advantage that it measures the difference in birth weight both in relation to the gestational-age-specific distribution and in relation to the "optimal" combination (indicated by lowest infant mortality rate), instead of using birth weight in absolute terms. The developers of this approach argue that it provides a solution to the assumption underlying the use of birth weight that the effect of difference in birth weights is identical regardless of its position on the distribution of birth weight.

Despite the great contribution of Solis et al.'s study, it had several limitations as the authors discussed in their paper: First, the study population was restricted to Caucasian girl infants in order to avoid confounding factors of gender and race/ethnicity. Second, for that study's own purpose of demonstrating an alterative measurement, it didn't control for any covariates. Therefore, their estimation of birth weight effects needs to be further tested when demographic and social covariates are accounted for. Finally their study used infant mortality as the sole outcome. The present study aims to test and expand Solis et al.'s analytical approach with regard to these three aspects.

Solis et al.'s approach in particular includes these following steps: transforming birth weight to a gestational-age-specific z-score scale, identifying the optimal combination of birth weight and gestational age that produces the lowest infant mortality rate, and then calculating the distance that each birth has from the optimal combination in relative weight. Finally the calculated deviations and their interactions are fit in the model, instead of birth weight per se.

4. **When Apgar scores are available:** The 5-minute Apgar score (developed over 50 years ago by Dr. Virginia Apgar) is a routinely performed means of evaluating the general physical condition of the newborn at 5 minutes after delivery. The score measures five easily identifiable infant characteristics—heart rate, respiratory effort, muscle tone, reflex irritability, and color, on a scale of 0,1 or 2, with 2 representing optimum behavior for each sign. The

Apgar score is the sum of the scores of the five components, and a value in the range of 7-10 is considered normal (CDC 2002). Several previous studies have demonstrated that Apgar score is a strong predictor for infant mortality, independent of birth weight, gestational age, and a large number of control variables (Doyle et al. 2003, Almond et al. 2005). Doyle and her colleagues (2003) also find that Apgar scores have a stronger predictive power for Mexicans and Caucasians than for African Americans, after controlling for covariates.

METHOD

Data: linked birth/infant death data 2001

The data used in this study come from National Center for Health Statistics (NCHS) linked birth/infant death file for 2001. This data set offers cohort information on infant mortality at the individual level for all births registered in the United States in 2001.[21] This dataset has rich information on birth outcomes (birth weight, gestational period, Apgar 5 score, and other detailed medical and health information) and parental demographic and socioeconomic background (race/ethnicity, age, education) based on birth certificates. Death certificates of those infants who died within that year are linked to the corresponding birth certificates. This data set excludes fetal death that means death prior to the complete expulsion or extraction from its mother of a product of human conception, irrespective of the duration of pregnancy and which is not an induced termination of pregnancy. This definition includes

[21] This study used 2001 birth cohort data, which consists of all the births in 2001 and linked deaths to infants born in 2001 regardless the death occurred in 2001 or 2002. In 2001, 98.8% of all infant death records were successfully matched to their corresponding birth records.

all the cases of stillbirth, spontaneous abortion, and miscarriage (NCHS: Technical Appendix-Fetal Death 2001). In 2001, there were 4,031,635 live births and 23,762 infant deaths in the United States (U.S. Territories are not included). An additional 250 deaths cannot be retrieved and linked back to their birth certificates due to a variety of difficulties; therefore, they are not included in the linked data set. In order to avoid the possibility of errors introduced by the classification of stillbirths as live births, I exclude those infants that simultaneously meet the following two conditions: less than 22 weeks of gestational age or weighed less than 500 grams at birth, and died within the first day after birth.[22] Table 11 presents the distribution of birth weight by gestational period of all the live white female infants.

A number of previous studies have suggested that the distributions of birth weight and gestational age, as well as their effect on infant mortality and other outcomes, differ considerably between sexes and across racial/ethnic groups (Joseph et al. 2005; Solis et al. 2000; Frisbie et al. 1996; Kline et al. 1989; Wilcox 1981; Wilcox and Russell 1986). Therefore, for the following analysis, I select a set of stratified sex- and racial/ethnic-specific groups: non-Hispanic white (hereafter "white") girls, white boys, non-Hispanic black

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[22] Previous research suggests that the greatest degree of error in reporting gestational age or birth weight is at the lower extreme of the distribution (Hummer 1999). Therefore, it is common for researchers to exclude some extreme cases. For example, Hummer et al. (1999)'s study restricted their cases to 500+ grams and 22+ weeks, and Solis and his colleagues (2000) restricted their cases to births of 28+ weeks and 500+ grams. It this study, I chose to adopt a more restricted criteria to exclude cases.

(hereafter "black") girls, black boys, Mexican girls, and Mexican boys. [23] Together there are 3,412,902 births in this study, representing approximately 85% of the total births in 2001. Figure 2 presents the distribution of birth weight by race and ethnicity at each gestational age. Figure 3 is a closer look at the birth weight distribution between 28 and 47 weeks of pregnancy, a range where black girls nearly always have the lowest birth weight in a given week, while white boys catch up and become the heaviest at week 36.

Measurement

Although prenatal care is measured in the data set by the modified Kessner index, this measure has been found to be very problematic because it does not distinguish between inadequacy due to late initiation and inadequacy due to an insufficient number of visits (Kotelchuck 1994a. 1994b). Instead, this study adopts a more precise measurement, the Kotelchuck Adequacy of Prenatal Care Use (APNCU) index, which is a four-category measure that most importantly, includes a high-risk "adequate plus" category of care that takes negative selection into account. [24] As Kotelchuck observed, both women with inadequate ratings and those with adequate plus ratings had increased LBW rates, which is because women who have problem pregnancies tend to visit doctors more often. APNCU is calculated based on the first visit, number of visits, and length of pregnancy, and adequate plus is defined as those who record more prenatal care visits than the standard recommended by the American College of

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[23] Maternal race/ethnicity is used to identify subgroups.

[24] The other three categories are inadequate, intermediate, and adequate care (definitions see Kotelchuck 1994).

Obstetricians and Gynecologists. This APNCU index has been adopted by a number of newer studies (Frisbie et al. 2004; Doyle et al. 2003; Finch 2003; Hummer et al. 1999).

Previous research has shown that first-born children have a higher risk of LBW (Miller 1994). As Kleinman and Kessel (1987) suggested, parity is measured by an index with three categories: first births, low parity (second-order births to women 18 and older and third-order births to women 25 and older), and high parity (second- or higher-order births to women under 18, third- or higher-order births to women under 25, and fourth- and higher-order births to women 25 and older), which takes into account the often mentioned interaction between maternal age and birth order (Hummer 1995; Hummer et al. 1999; Finch 2003; Doyle et al. 2003; Frisbie et al. 2004). Analysis of this data set shows no collinearity problem between the measure of parity and maternal age.

Nonlinear effects of parental age on infant outcomes have been well documented, so both maternal and paternal age were included and categorized in three groups: less than 20 years, between 20 and 34 years, and older than 34 years (Reichman et al. 2006). Maternal educational attainment has been shown to have a profound effect on both the number of births and the risk of adverse birth outcomes (Martin JA., et al. 2002). It was also categorized into three groups: less than high school (less than or equal to 9 schooling years), high school (between 9 and 12 years), and some college or beyond (more than 12 years). Furthermore, income is not available in vital statistics records, so maternal education is frequently used as a proxy for the socioeconomic status in this type of study (Hummer et al. 1999; Doyle et al.

2003). Children born to unmarried mothers have been found to have a higher LBW rate (Hessol et al. 1998), so an indicator of marital status was included in the analysis.

Outcomes include whether each infant born alive died within seven days since birth (early neonatal mortality), between 8 and 27 days (late neonatal mortality), and between 28 and the first birthday (postneonatal mortality). Table 10 presents mortality rates of each racial/ethnic group at different time periods. In general, blacks have significantly higher mortality rates at each time period than whites and Mexicans, and girls have lower mortality rates than boys of each racial/ethnic group, at any given period except for blacks' late neonatal mortality rate.

Analysis

As the first step of systematically reviewing these alternative approaches, I identified thirteen birth outcome measures as key independent variables that are applicable to the natality data set: continuous birth weight (grouped to every 100 grams), LBW (a dichotomized variable), a four-category combination of birth weight and gestational age, FGR (a dichotomized variable of whether the FGR is greater than 0.85, calculated as a ratio to the mean birth weight of an appropriate sex-, racial/ethnic-, and gestation-age-specific [week-by-week] standard), standardized gestation-age-specific birth weight, and Apgar score. Table 12 depicts the key identified birth outcome measures to be examined at the next analysis step on the 2001 linked birth/infant death data set. Other techniques that involve other physical measures at birth (such as length or head circumference) are not tested because of the lack of the information in this particular data set. The approach Solis and his colleagues proposed will be discussed separately. Table 13 presents the descriptive statistics of covariates and key birth outcome measures for each gender- and race-specific group.

Following a descriptive analysis, I employed multivariate logit models to assess the associations between the 13 key measures with the three outcomes (early neonatal, late neonatal, and postneonatal mortality), after accounting for the same set of covariates including parental characteristics (maternal age, maternal education, marital status, if mother was born in US, if father was unreported on birth certificates), maternal behaviors (adequacy of prenatal care, tobacco/ alcohol use during pregnancy[25]), and child characteristics (parity). These techniques are first assessed within each of the sex- and racial/ethnic groups, and then compared across groups. All coefficients for the logit regression analyses are reported in the form of odds ratios of mortality.

RESULTS

Results of analysis using the multivariate logit models show that risk factors (both covariates and birth outcome measures) for infant mortality differ both by race/ethnicity and by time after birth.

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[25] California doesn't report maternal smoking or drinking on its birth certificates; therefore missing indicators for these two risk factors are included for California, which measure both the effect of missing smoking/drinking and of California. A dummy variable with '1' for missing and '0' for not missing is entered into a regression analysis alongside the new explanatory variable (i.e., the one with missing values assigned to the series mean), which provides information on whether or not the cases assigned missing values differ from those without missing values on the outcome variable. This procedure also adjusts the estimate of the explanatory variable so that it is not biased by the missing values assigned. This is a standard method of dealing with missing data. Unfortunately, it also produces biased estimates of the coefficients (Allison 2001).

Covariates

Tables 14-31 present a series of analytic results for each of the three outcomes: early neonatal, late neonatal and postneonatal mortality. Each table contains the results for all 13 models, for one of the three outcomes and one of the six groups (white girl, black girl, Mexican girl, white boy, black boy, and Mexican boy). Covariates, as risk factors for mortality, differ by both race/ethnicity and by time after birth. Here, I summarize some observations about key covariates for each outcome and group.

For all three mortality rates (outcomes), white female infants born to mothers with at least a college education persistently (for all models) show statistically significant positive associations with less mortality, compared to those with high school education. For example, for early neonatal mortality of white female infants (Table 14), maternal college education reduces the risk of death in a range between 12% (OR: 0.88 at 90% significant level) for model 1, and 27% (OR: 0.73) for model 8. Inadequate, intermediate, and adequate plus (too much) care are all found to be related to higher risks for mortality than those received adequate care. Smoking during pregnancy, counter-intuitively, is found to be associated with lower mortality odds. This observation was explained by Wilcox that the paradox was artifact due to comparison of absolute weights, and it can be solved by using relative weights on a z-score scale (Wilcox 2001).

The most significant predictors for black girls' early neonatal mortality are marital status and unreported father. Each is positively associated with a higher risk of mortality across all models. None of the covariates show persistent significant associations with Mexican girls' early neonatal mortality across all models. Unreported father, high parity, and plus adequate care are related to higher mortality odds for some models in this time period.

Not much gender difference in covariates' predictive power is found in blacks and Mexicans. However, within whites, however, boys are found to have a different set of risk factors from girls: mother older than 34, maternal education less than high school, unreported father, high parity, inadequate care, intermediate care, and plus care are all found to associate with higher chance of early neonatal death. First birth, on the other hand, is related to lower odds of death (Table 23).

Covariates' import varies over time as well: both mothers older than 34 and high parity, neither of which is associated with early neonatal death rates, are correlated with higher late neonatal mortality risks for white girls. For postneonatal mortality of white girls, mothers younger than 20, unreported fathers, high parity, inadequate care, intermediate care, adequate plus care, and tobacco use during pregnancy are found to be significantly associated with higher chance of death, and married mother, maternal education of college or above, and first birth are related to lower chance of death.

There are a few covariates that show a significant and constant impact across all three outcomes, although they differ by group. For white girls, maternal education at least through college is the only variable that persistently correlates with lower death likelihood. Similarly, unreported father significantly associates with higher mortality odds of black girls in all three time periods and first birth shows continual associations with lower death likelihoods for white boys, independent of time period.

One additional interesting finding with regard to covariate is that first birth, previously thought as a risk factor for greater odds of mortality, is significantly associated with lower postneonatal mortality likelihood for most or all models within each racial/ethnic- and sex-specific group compared to low parity, despite not always being associated with early or late neonatal mortality odds.

Key measures of birth outcomes

Not surprisingly, birth outcomes are found to have a greater and persistent effect on infant mortality than maternal factors and other covariates in each subgroup. This is shown by the statistical significance of each outcome, as reported in Tables 14-31. Birth weight, LBW, gestational age, and classifications of combinations of birth weight and gestational age are all found to have salient effects on early neonatal mortality likelihood. For instance, as shown under model 5 in Table 14, white female infants born preterm and LBW (<37 weeks and <2500 g) have early neonatal odds of death 78 times greater than those born on term (≥37 weeks and ≥2500 g). Similarly, those born large-for-gestational age (<37 weeks but ≥2500 g) are 4 times as likely, and those born IUGR (≥37 weeks and <2500 g) have 16 times greater odds of early neonatal mortality than those born on term.

In terms of the relative predictive power of a model, indicated by R-squared, models using classifications of combinations of birth weight and gestational age don't show superiority over models simply using birth weight or birth weight combined with gestational age. Among all measures of either or both birth weight and gestational age, the standardized gestation-age-specific birth weight (model 7) performs poorly; though this measure *per se* is a significant predictor of mortality in each period, the model's goodness-of-fit is far lower than any other model, for each time period and group.

When Apgar scores are included to the models, not only do Apgar scores *per se* show considerable effect on early neonatal mortality, independent from birth weight and gestational age, but also they significantly improved the models' goodness-of-fit. For instance, model 12 of Table 13 shows that white girl infants with low Apgar scores have 413 times and those with medium scores had 37 times greater odds of early neonatal death than those with high Apgar scores. In this model, preterm LBW, large-to-gestational age, and IUGR retain their significant effects on mortality but at a much reduced magnitude compared with model 5, where Apgar scores are not included. Within each racial/ethnic- and gender-specific subgroup, Apgar scores are the strongest predictors of early neonatal mortality, and models employing Apgar scores, birth weight, and gestational age have the most predictive power. However, it is noteworthy that Apgar scores have a stronger predictive power for Mexicans and whites than for blacks: for example, when only Apgar scores are included as key birth outcome measures (model 9), the odds ratios of low and medium Apgar scores, compared to high Apgar scores, for early neonatal death of white or Mexican girls (model 9 in Table 14 and 20) are more than double that of black girl infants (model 9 in Table 17). Apgar scores also have a greater predictive power for girls than boys. Take white infants as an example: Odds ratios of low and medium Apgar scores for girls neonatal mortality (OR: 1254, OR: 104, respectively) are much greater that that of white boys (OR: 980, OR: 75, respectively, model 9 in Table 23).

When comparing models across the three time phases, although all birth outcome measures remain significantly associated with mortality, most measures' predictive power reduces drastically over time. Apgar scores, in particular, experience an enormous reduction in their coefficients on mortality: Odds ratios of low Apgar scores are 1,254 for early neonatal death, 83 for late neonatal death, and 29 for postneonatal death of white girls (model 9 in Table 14-16). Statistical measure of R-squared of all 13 models decreases significantly over time periods, meaning less variation in late neonatal and even less variation in postneonatal mortality are explained by the included covariates and key birth outcome measures.

DISCUSSION/CONCLUSION

In this review of birth outcome measures and multiethnic statistical analysis, I find considerable racial and ethnic differences in both risk factors and mortality across the first year of life. These variations together may lead to ethnic differences in causes of infant death, and therefore preventions and interventions aiming to reduce mortality may differ across racial- and gender-specific groups.

The first interesting finding is that covariates as risk factors vary by race, gender, and time period. Maternal education at least through college is significantly associated with lower mortality of white girls in all three time phases, while the most significant predictor for black girls' mortality is missing father's information. For white boys, first birth is always associated with lower risk of death in each time period. From the research perspective, this raises a caveat about the traditional regression modeling approach: since covariates may have different effects for certain racial/ethnic groups, a regression that attempts to assess racial differences by including categorical variables for races/ethnicities will either need to include interaction terms of race and covariates, or allow coefficients of those covariates to differ for each racial/ethnic group. If neither is incorporated, the produced coefficients of covariates may be biased, but also we would not be able to tell whether the covariates matter for all or just some of the racial groups. Using such research results suggest that, from a policy perspective, programs will be designed that misallocate resources by over- or underestimating the need for an intervention. Conversely, identifying the risk factors appropriate to race- and gender-specific subpopulations will help to design effective programs.

Covariates' import also differs over time. In particular, first birth, compared to low parity, was suggested as a high risk factor for infant mortality by previous research. However, results of this study show first birth is always significantly associated with lower risk of postneonatal mortality in each subpopulation, while this association between first birth and early neonatal or late neonatal mortality is inconsistent. This implies that other risk factors (such as predicted by low Apgar score or birth weight) are more significant predictors of mortality in the first week. However, because infant first births may attract more attention from parents, throughout their first year of life, than those second or higher parity births to their families, this additional attention may reduce the risk of injury and accidents. Hessol and Fuentes-Afflick (2005) also observed that first birth was associated with lower risk for postneonatal but not for neonatal mortality. Without further analysis of first births, they suggested that women with more than 3 prior live births might be less attentive or more complacent about infant health care and those high parity infants a had higher risk for death of sudden infant death syndrome (SIDS) in postneonatal period. Additional research, incorporating specific causes of infant death, will be useful as a means to better understand the true significance of this observation. This finding also suggests that some risk factors such as first birth may have opposite effects in different time periods. Therefore, the use of infant mortality as one single outcome may be *questionable*. In this particular case, the misperception of first birth as a risk factor may overshadow the risk of low parity in the postneonatal period.

Another example of a risk factor varying over time is maternal smoking behavior during pregnancy. Previous research into the “smoking paradox” has found that when using absolute birth weights, small babies of mothers who smoke seem to be at lower risk. Wilcox argued that the paradox was due to the residual distribution of birth weight on the very left tail, and he demonstrated that using relative birth weight on a z-score scale would shift both birth weight and mortality curves, and would then show that smoking is harmful. The results of this study show that while smoking is associated with lower risk for early neonatal mortality (the smoking paradox), it is significantly associated with higher risk for postneonatal mortality in each race- and gender-specific group. This analysis doesn’t demonstrate that the effect of smoking changes direction over time, because models accounting for the smoking paradox were not included. However, it may imply that the effect of residual distribution of birth weight is a relatively minor concern for infants who survive beyond the early neonatal period.

All birth outcome measures examined in the 13 models are much stronger predictors than maternal characteristics and other covariates in each subpopulation and each time period. Low and medium Apgar scores remain the strongest predictors among all models in all time periods, independent from birth weight and gestational age. However, both Apgar scores' predictive power and the variation in outcomes that can be explained by included explanatory variables decline considerably over time. It is plausible that since Apgar score measures newborn's physical conditions directly by physicians, it is a more relevant predictor for immediate death risk than birth weight or gestational age, which to some extent are relative measures depending on many other factors such as mother's physical size. However, as infants with lower Apgar score survive the first 7 days and firth month since birth, their risk of death lessens.

It is noteworthy that, as with previous research findings, Apgar score predictive power is stronger for Mexicans, whites, and girls than for blacks, and boys. In part, the ethnic discrepancy may be explained by the artificially suppressed Apgar score for blacks—black infants have higher proportions of both low and medium Apgar scores compared to Mexicans and whites, which might be due to the "color" component, because it is hard for black infants to appear "pink" (Yama & Marx 1991; Doyle 2003). Therefore, future research is needed to further investigate the association between each of the five components of Apgar score and outcomes.

The so-called "optimal combination" approach proposed the study of Solis, et al. (2000) deserves some discussion. As described previously in the review section, Solis and colleagues demonstrated their approach on a subpopulation of white female infants. I applied their approach to other race- and gender-specific subgroups, and found that although this approach is appealing in theory, it is not feasible in practice, especially when applied to non-white subgroups. An essential step of their approach is identifying the optimal combination of birth weight and gestational age that produces the lowest infant mortality rate, and then calculating the distance of any particular birth weight to the "optimal" combination. However, as figures 4 and 5 show, where the infant mortality rate is mapped on dimensions of birth weight and gestational age for black female and black male infants, respectively, the optimal combination of birth weight and gestational age can be very scattered, which make it impossible to identify one point or a concentrated area that produces the lowest mortality rate. Further, standardizing birth weight to a gestational-age-specific z-score scale doesn't produce a smooth reverse J-shape infant mortality rate curve that enables identification of the minimum, as showed in Solis et al.'s paper. To smooth the data, many cases, especially those "outliers" that are of research interest, will need to be deleted from the data set. Thus, while this "optimal combination" approach is compelling in theory, the key step where the optimal combination of birth weight and gestational age is identified is found to be rather subjective, and can hardly be universal across subgroups.

In sum, the results of this study suggest a rule of thumb for researchers. When predicting infant mortality odds, if Apgar score is available, it should be always included along with certain classifications of combination of birth weight and gestational age; if Apgar score is not available, for postneonatal death, it makes little difference to just use combination of birth weight and gestation age, but a large difference for early and late neonatal mortality.

Finally, the results show that risk factors vary by race/ethnicity, gender, and time, which suggests a need to tailor prevention and education efforts, especially during the postneonatal period.

CHAPTER 5 – Conclusions: research and policy implications

This dissertation provides a plethora of implications and recommendations for both researchers and policy-makers. These are highlighted below. Limitations of this study and suggestions for further research are also discussed.

Implications for research

In the second chapter, this study uses a propensity scoring estimation method to investigate the differences in three birth outcomes (birth weight, LBW rate, and 5-minute Apgar score) of infants born to non-Hispanic black, non-Hispanic white, and Hispanic mothers of Mexican origin in the United States in 2001. Propensity score estimation in effect re-weights the empirical distribution of the covariates of the comparison group (non-Hispanic white or Mexican) in such a way that the distribution of the resultant synthetic white or Mexican population is approximately coincident to the actual non-Hispanic black distribution. However, despite theoretical concerns regarding the use of ordinary least squares (OLS), I did not find significant differences between the results produced by the two methods, with statistically *insignificant* differences. While after introducing nonlinear forms and interactions to the regression model, the results of regression become closer to that of propensity score estimation.

This study demonstrates both pros and cons of the two methods. Propensity score estimation is practically simpler in terms of modeling, since it doesn't require specific forms and interactions of variables. It is also a very useful diagnostic tool: when the covariates vary largely across groups, it won't produce results. In contrast, regressions would require enormous modeling efforts but it still yields results, though possibly biased, when covariates distribute very differently across groups. Therefore, propensity score estimation can be a powerful tool to assess the membership effect on outcomes, in our case, the racial effect. However, for social scientists and policy researchers, people often want to know not only the key independent variable's effect, but also covariates' effect as risk factors. Propensity score estimation uses covariates to match groups rather than provides estimation of their effects. In this sense, regression modeling has its advantage. As a recommendation for researchers, using regression modeling without carefully examining nonlinear forms and interactions may lead to biased estimation. Therefore, it should be assisted with propensity score estimation to determine the efficacy and sensitivity of the regression analysis.

The results of the third chapter suggest the common practice of using maternal race and ethnicity to refer to race and ethnicity of the infant is problematic: infants born to white mother and white father have the best birth outcomes among the groups studied, so any other paternal race/ethnicity pulls down the averages for all white mothers. That is, the birth outcomes of white mother and white father are actually *underestimated* and thus the racial and ethnic disparities between white and any other race or ethnicity may be *underestimated* accordingly as well. This suggests a second recommendation for researchers; when using data collected before the 1997 OMB standards are widely implemented and accepted, researchers need to be clear and cautious if using maternal race/ethnicity to refer to child's race/ethnicity.

In the fourth chapter, the results suggest the predictive power of both covariates and key birth outcome measures for mortality vary over time. Apgar score remains the strongest predictor for mortality among all key birth outcome measures, although its predictive power declines considerately over time, based on the findings from chapter 2 and 4. In sum, the third recommendation for researchers is a rule of thumb that, if Apgar score is available, it should be always included when predicting infant mortality odds, along with certain classifications combining birth weight and gestational age. If Apgar score is not available, it makes little difference to just use an appropriate combination of birth weight and gestation age for predicting postneonatal death, but a large difference for predicting early and late neonatal mortality.

Finally, this dissertation has several limitations due to the nature of available data. For instance, ECLS-B has a skewed sample: only those who survived the first 9 months were included. Therefore, the outcomes of interest in this sample are better than the actual national level. Also, the estimated race differences in outcomes may be smaller than the real differences. On the other hand, the death/birth linked data in 2001, despite many advantages, suffers from the lack of parental socioeconomic variables such as income and parental physical variables such as height.

The limitations and results together shed some light on future data collection needs, which can be partly addressed with appropriate policies. At the state level, I recommend a carefully designed universal birth certificate, on which the following additional data should be collected: both maternal and paternal weight and height, the reason for a missing father on the certificate, and infant height and head circumference at birth. This would also require California to include Apgar score, and maternal smoking and drinking behaviors during pregnancy on its birth certificate. Having this additional information will enable researchers to conduct a more thorough investigation on race differences in birth outcomes. At an individual data collection level, I suggest paying more attention to father's role during and after pregnancy, such as the father's wanting the baby, his interaction with the mother and infant, father's own health behaviors and his influence on mother's behavior, and father's physical conditions. I especially encourage data collection and analysis to investigate why so many fathers are currently missing from birth certificates. Are they just missing from the certificates? Is so, what can we do to increase the report rate? Or, are they missing completely from the infants' lives and what are the consequences and implications for policy?

In either case (state and individual data collection), I also suggest to collect not only Apgar scores *per se*, but each of the five components. Then researchers will be able to identify if color is the reason why blacks have much lower scores, and they will be also able to link particular physical condition to infant mortality.

Implications for policy

In general, this study finds a large racial gap in birth outcomes regardless of which method is used. This remaining large racial/ethnic disparity in birth weight, after accounting for confounding factors regardless which method was used, suggests that more attention is needed to prevent adverse birth outcomes. In particular, this dissertation provides the following policy implications and recommendations.

First, the third chapter finds that there are great variations within the white mother group, especially across education and behaviors, counter to the common conception that white mothers have lower risk for poor infant health. This implies that prenatal interventions need to pay more attention to the disadvantaged mothers within all racial and ethnic groups, even when the particular race/ethnicity is normally not considered as at risk.

Second, although the results show little effect of paternal race/ethnicity on outcomes, missing father data is found to be highly associated with poor health outcomes at and after birth. An especially high proportion of black infants are born without fathers reported on their birth certificates, and the association between unreported father and disadvantaged outcomes is the highest for blacks among all racial/ethnic groups, based on the results of both chapter 3 and 4. Although the exact pathways of how unreported fathers would affect infant health at birth are not definite, one possibility is that infants in this group are "unintended" births (either sooner than planned or unwanted at all), and they are likely to receive less care than "intended" infants, both during pregnancy and after birth. Unintended pregnancy can carry serious consequences at all ages and life stages. Therefore, policies and programs need to be carefully designed to address how to improve the unintended infant's health. One possible intervention conceived with this unwanted pregnancy concern in mind is for doctors or social workers to help facilitate the mother's access to prenatal and postnatal care, better nutrition, and behavior counseling. A long-term policy might focus on prevention of such pregnancies.

Finally, the results in Chapter 4 show that risk factors vary by race/ethnicity, gender, and time, which suggests a need to tailor prevention and education efforts, especially during the postneonatal period, since the importance of certain risk factors is observed to change across groups over time. In order to achieve national goals of reducing infant mortality rates and eliminating ethnic disparities, ethnic-specific strategies may need to be designed and implemented targeting the exact risk factors. In particular, an ethnic-, gender- and time-specific risk factor checklist can be developed, so the importance of certain risk factors can be emphasized at the appropriate time.

These results, taken in combination, lead to the conclusion that policy makers need to not only continue focusing on closing the recognized gap between black and other racial/ethnic groups in birth outcomes, but also pay more attention to subpopulations that are traditionally not considered as at risk and certain time periods that are previously regarded as less risky.

Figures

Figure 1: Birth weight distribution, white vs. black, 2001 live births in US

(Data: Linked live birth/infant death data set 2001)

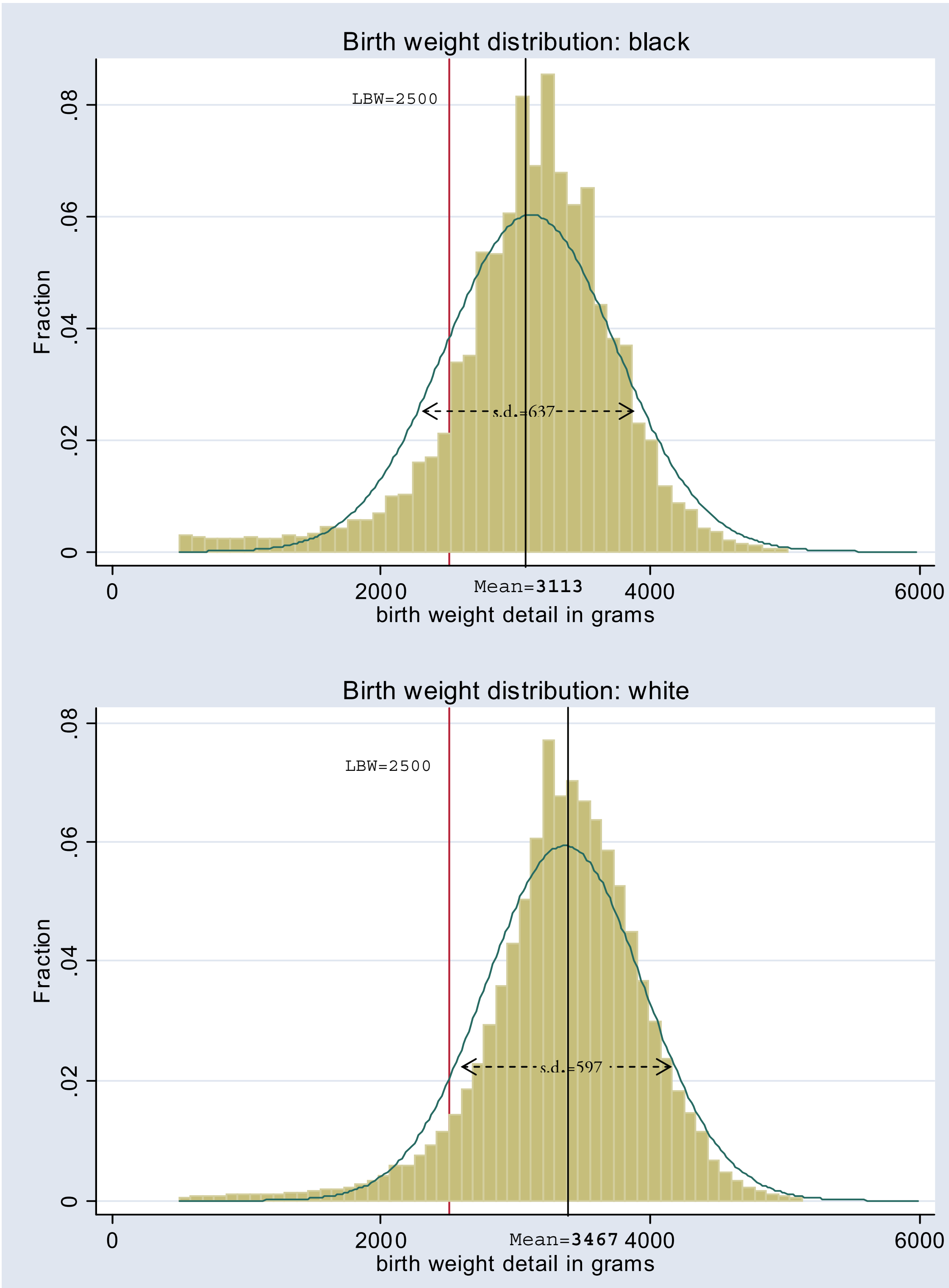
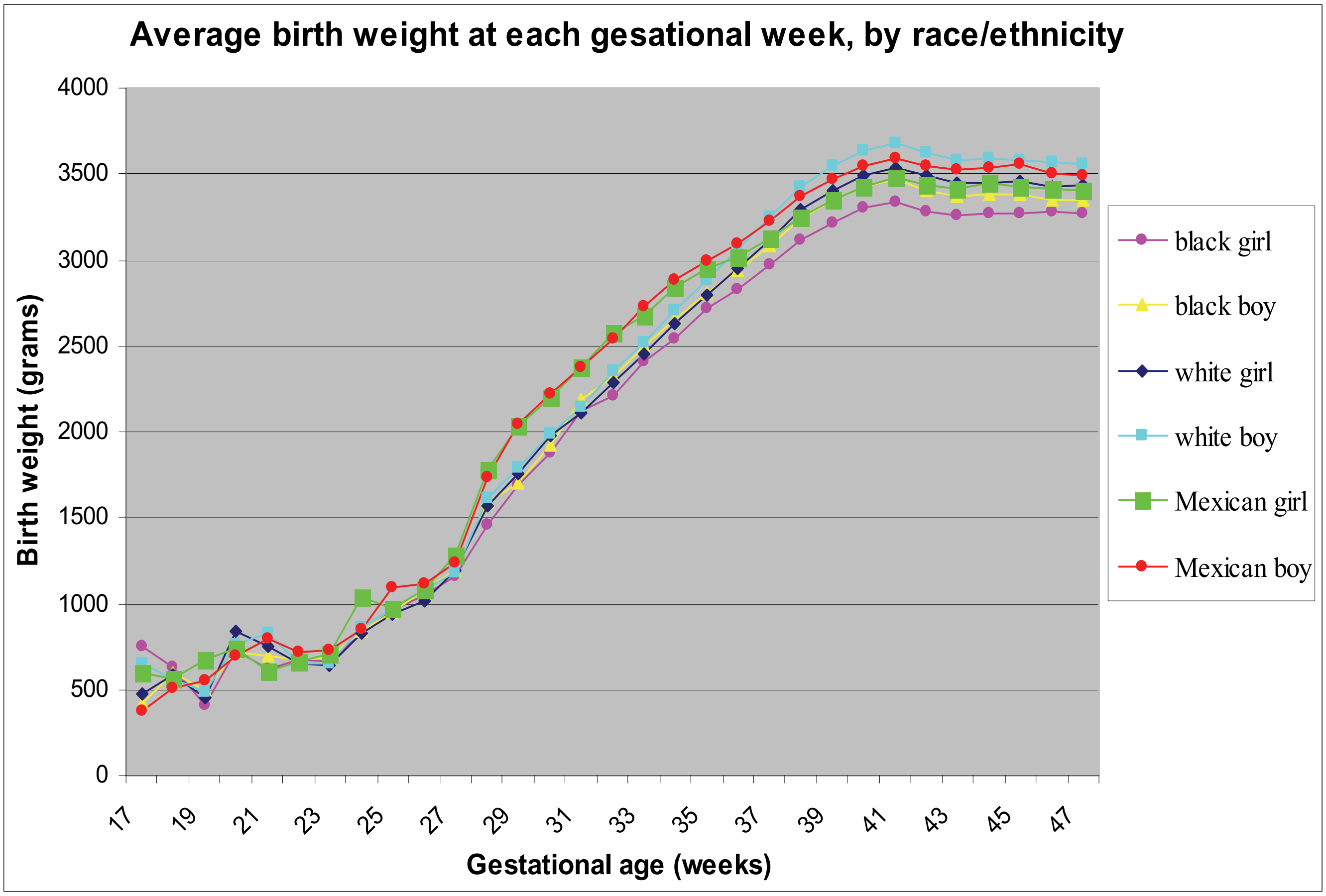
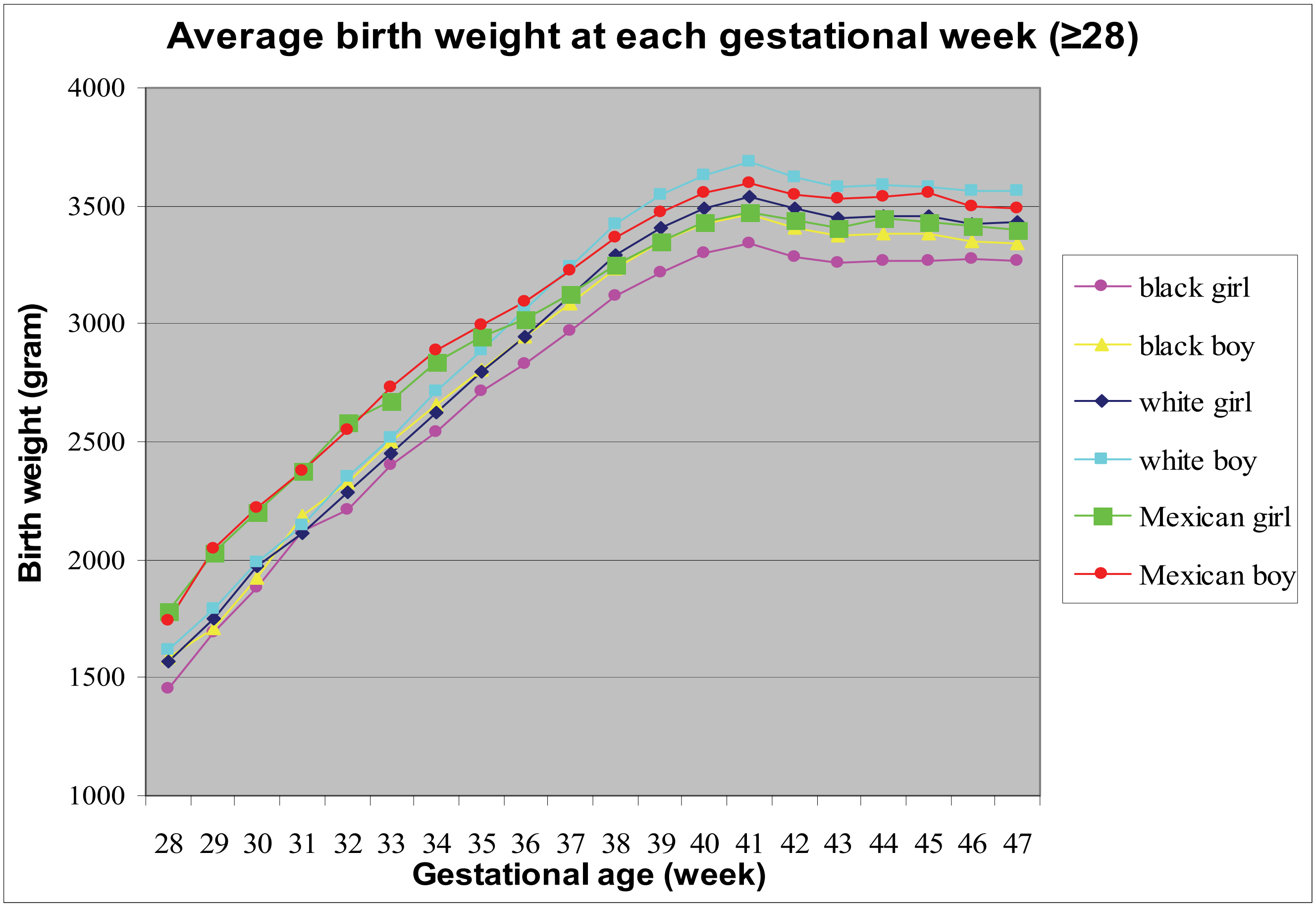


Figure 2: Average birth weight at each gestational week, by race/ethnicity



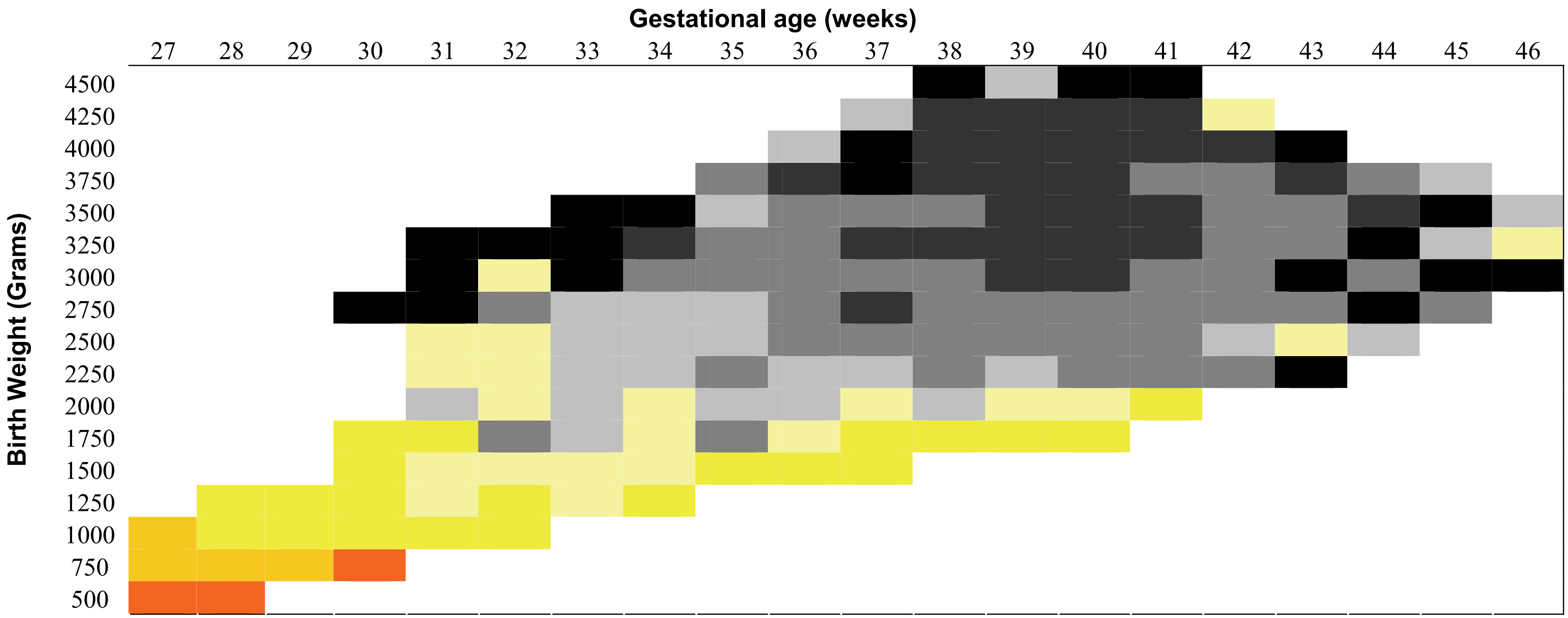
Note:
Data: Linked live birth/infant death data set 2001

Figure 3: Average birth weight at each gestational age (≥28 wks)



Note:
Data: Linked live birth/infant death data set 2001

Figure 4: A demonstration of Solis. et al's approach on black female infants in 2001.



Note: Data: Linked live birth/infant death data set 2001

IMR Levels (x1000)

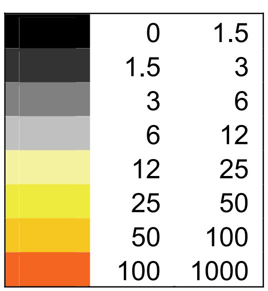
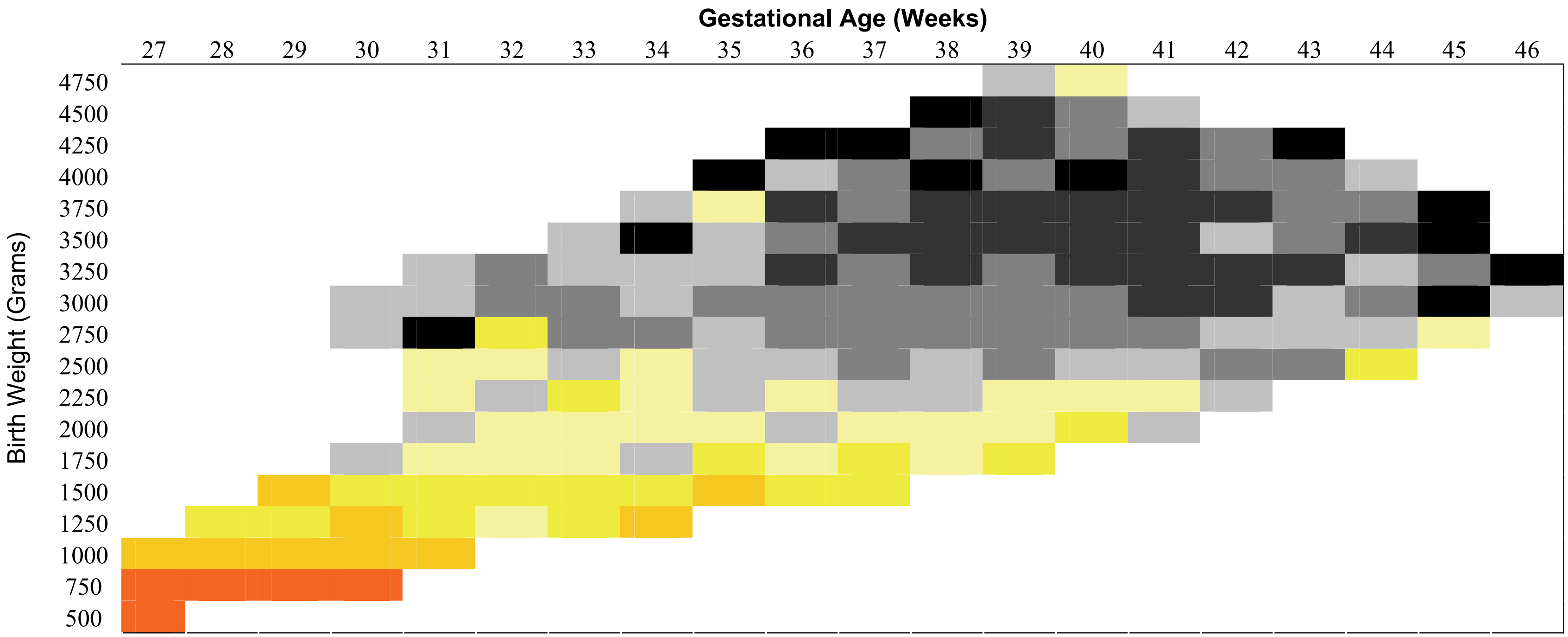
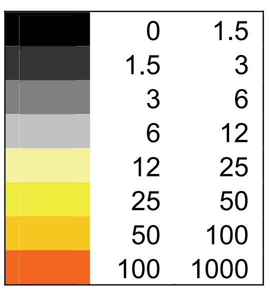


Figure 5: A demonstration of Solis. et al's approach on black male infants in 2001.



Note: Data: Linked live birth/infant death data set 2001

IMR Levels (x1000)



Tables

Table 1: Comparison of black vs. white, black vs. Mexican

	Reference group **Black** N=1,592		Comparison group 1 **White** N=4,569		Comparison group 2 **Mexican** N=918	
COVARIATES	**Mean**	**Sd**	**Mean**	**Sd**	**Mean**	**Sd**
Mother is married	0.32	0.47	0.78	0.41	0.62	0.49
Mother's age	25.28	6.27	28.07	6.05	25.91	5.9
Mother's weight	155.85	41.47	148.11	34.38	140.92	33.32
Mother's height	64.77	2.81	65.06	2.77	62.97	2.93
Mother's education	12.41	2.13	13.72	2.29	10.49	3.34
Mother US born	0.89	0.32	0.96	0.2	0.41	0.49
Prenatal care visits	10.82	4.25	11.96	3.49	11.05	4.38
County population	1.77	1.44	2.43	1.5	1.07	1.41
SES	-0.48	0.76	0.17	0.77	-0.6	0.59
Poverty	0.45	0.5	0.13	0.34	0.36	0.48
Total birth order	2.22	1.4	1.95	1.05	2.2	1.27
Gestational period	38.43	3.47	38.85	2.83	38.82	2.71
Twins	0.03	0.21	0.03	0.25	0.02	0.19
Female	0.5	0.5	0.49	0.5	0.48	0.5

Note: This table presents statistics of actual covariates of reference group (black) and comparison groups (white/ Mexican).
Data: ECLS-B, 9-month

Table 2: Comparison of black vs. white, black vs. Mexican, after using the propensity score weighting

	Reference group **Black** N=1,592		Comparison group 1 **Weighted White** ESS=1012		Comparison group 2 **Weighted Mexican** ESS=311	
COVARIATES	**Mean**	**Sd**	**Wt. Mean**	**Wt. Sd**	**Wt. Mean**	**Wt. Sd**
Mother is married	0.32	0.47	0.33	0.65	0.45	0.52
Mother's age	25.28	6.27	25.5	6.65	25.21	6.04
Mother's weight	155.85	41.47	155.58	40.63	156.44	43.77
Mother's height	64.77	2.81	64.9	2.8	64.51	3.26
Mother's education	12.41	2.13	12.5	2.34	12.27	2.7
Mother US born	0.89	0.32	0.92	0.28	0.87	0.54
Prenatal care visits	10.82	4.25	11.19	4.26	10.74	4.42
County population	1.77	1.44	1.9	1.59	1.48	1.43
SES	-0.48	0.76	-0.39	0.93	-0.37	0.72
Poverty	0.45	0.5	0.39	0.54	0.37	0.48
Total birth order	2.22	1.4	2.04	1.15	2.07	1.26
Gestational period	38.43	3.47	38.68	3.07	38.66	2.88
Twins	0.03	0.21	0.03	0.25	0.02	0.18
Female	0.5	0.5	0.51	0.5	0.46	0.5

Note: This table presents statistics of actual covariates of reference group (black) and statistics of weighted comparison groups (white/ Mexican). The propensity-score weights were calculated separately for each comparison group.

Data: ECLS-B, 9-month

Table 3: Gender Comparison, before and after weighting

	Reference		Comparison Group			
	Female		**Male (before weight)**		**Male (after weight)**	
	N=4,498		N=4,662		ESS=4,662	
COVARIATES	**Mean**	**Sd**	**Mean**	**Sd**	**Wt. Mean**	**Wt. Sd**
Mother is married	0.69	0.46	0.67	0.47	0.67	0.47
Mother's age	27.40	6.09	27.23	6.25	27.23	6.25
Mother's weight	148.16	36.45	145.82	34.68	145.89	34.72
Mother's height	64.55	2.99	64.58	2.85	64.58	2.85
Mother's education	13.05	2.72	12.99	2.78	12.98	2.78
Mother US born	0.82	0.39	0.82	0.39	0.82	0.39
Prenatal care visits	11.60	3.72	11.64	3.87	11.64	3.87
Total birth order	2.05	1.18	1.99	1.13	1.99	1.13
County population	2.08	1.56	2.01	1.54	2.01	1.54
SES	-0.06	0.81	-0.04	0.81	-0.04	0.81
Poverty	0.22	0.41	0.21	0.40	0.21	0.41
Total birth order	2.05	1.18	1.99	1.13	1.99	1.13
Gestational period	38.83	2.83	38.73	2.79	38.73	2.80
Twins	0.03	0.22	0.03	0.21	0.03	0.21
Black	0.15	0.36	0.14	0.35	0.14	0.35

Note: This table presents statistics of actual covariates of reference group (female infants) and statistics of comparison groups (male infants), before and after applying propensity score weights.
Data: ECLS-B, 9-month

Table 4: Summary of birth outcomes comparisons: black vs. white/Mexican groups

OUTCOME	Reference Group Black N=1,592		Comparison Group 1 Wt. White ESS=1,012		Comparison Group 1 White N=4,569		Comparison Group 2 Wt. Mexican ESS=485		Comparison Group 2 Mexicans N=1,351	
	Mean	Sd	Wt. Mean	Wt. Sd	Mean	Sd	Wt. Mean	Wt. Sd	Mean	Sd
Birth weight	3,116.61	785.7	3,339.01	736.4	3,377.58	727.68	3,354.601	709.17	3,326.646	642.75
(C.I.) [a]	(3077.99	3155.24)	(3293.58	3384.43)	(3356.48	3398.69)	(3291.33	3417.87)	(3292.341	3360.951)
LBW rate	11.80%	0.42	7.90%	0.34	6.40%	0.33	5.80%	0.29	5.80%	0.29
(C.I.)	(9.7%	13.9%)	(5.8%	10.0%)	(5.4%	7.4%)	(3.2%	8.4%)	(5.7%	6.0%)
Apgar 5 [b]	8.90	0.81	8.92	0.65	8.93	0.65	8.92	0.46	8.96	0.5
(C.I.)	(8.86	8.94)	(8.88	8.96)	(8.91	8.95)	(8.84	9.00)	(8.91	9.01)

Note: This table presents comparisons between reference group (black) and comparison groups (white/Mexican).

a. Confidence interval is calculated at 0.95 significance level.

b. Apgar score for Mexican is calculated on all states but California and Texas.

Data: ECLS-B, 9-month

Table 5: Comparison of racial effect on birth outcomes, between the two methods, across racial/ethnic groups

	Propensity score estimate	OLS estimate	Confidence interval of the regression coefficient [a]	Diff [b] (grams)	N
I. Birth weight: Propensity Score *vs.* OLS					
Black vs. white [c]	-222**	-200**	(-238.58 -161.53)	22	6,161
Black vs. Mexican	-238**	-195**	(-250.91 -139.29)	43	2,943
Mexican vs. white	-36	-24	(-75.74 28.54)	12	5,920
II. LBW rate: Propensity score vs. logit					
	Propensity score estimate	logit predication	Confidence interval of the logit prediction	Diff (%)	N
Black vs. white	3.90%*	5.39%**	(4.27% 6.51%)	1.49%**	6,161
Black vs. Mexican	5.96%**	6.00%**	(4.66% 7.44%)	0.04%	2,943
Mexican vs. white	0.83%	0.64%	(-0.32% 1.61%)	-0.19%	5,920
III. Apgar score [d]: Propensity Score vs. OLS					
	Propensity score estimate	OLS estimate	Confidence interval of the regression coefficient	Diff (point)	N
Black vs. white	-0.01	0.097**	(0.04 0.16)	0.107**	5,667
Black vs. Mexican	-0.02	-0.086	(-0.19 0.01)	-0.066	1,834
Mexican vs. white	-0.01	0.185**	(0.09 0.28)	0.195**	4,565

Note: ** p< 1%; *p<5%.

a. Confidence interval is calculated at 0.95 significance level.
b. Diff denotes the difference in estimation of racial effect between the two approaches.
c. The former (in bold font) is the reference group; the latter one is the reference group.
d. Apgar score is calculated for all states but California and Texas.

Data: ECLS-B, 9-month

Table 6: An Overview of Average Birth Weight of Biracial Infants (NCHS Linked birth and infant death file 2001)

	Maternal Race and Ethnicity											
	Non-Hispanic Black				Non-Hispanic White				Mexican			
Paternal Race	mean	C.I.	n	%	mean	C.I.	n	%	mean	C.I.	n	%
Black	**3131.0**	(3128.8 3133.2)	351,320	59.54%	3323.1	(3317.6 3328.5)	48,484	2.08%	3309.8	(3295.8 3323.7)	7,685	1.25%
White	3216.2	(3205.0 3227.4)	12,867	2.18%	**3378.0**	(3376.2 3377.8)	1,958,045	84.14%	3376.2	(3370.6 3381.9)	40,707	6.61%
Mexican	3181.1	(3157.0 3205.2)	2,539	0.43%	3330.3	(3325.5 3335.2)	54,134	2.33%	**3338.4**	(3336.8 3340.0)	465,387	75.59%
Puerto Rican	3154.0	(3130.5 3177.4)	2,718	0.46%	3307.6	(3296.2 3319.0)	10,200	0.44%	3310.8	(3287.7 3333.9)	2,436	0.40%
Central or South American	3198.4	(3166.7 3230.1)	1,528	0.26%	3344.5	(3332.2 3356.8)	9,169	0.39%	3335.7	(3326.1 3345.3)	13,858	2.25%
Cuban	3164.9	(3076.2 3253.7)	215	0.04%	3354.0	(3326.3 3381.7)	1,788	0.08%	3326.2	(3283.5 3368.9)	795	0.13%
East Asian [1]	3202.4	(3079.6 3325.2)	123	0.02%	3318.5	(3299.2 3335.9)	3,520	0.15%	3318.5	(3272.8 3364.3)	528	0.09%
Asian Indian	3123.2	(3028.0 3218.4)	173	0.03%	3287.0	(3254.0 3320.0)	1,149	0.05%	3361.6	(3275.2 3447.9)	179	0.03%
American Indian	3233.0	(3180.7 3285.3)	548	0.09%	3341.0	(3330.1 3351.8)	11,412	0.49%	3321.7	(3293.9 3349.5)	1,822	0.30%
Missing	3039.6	(3036.8 3042.5)	213,750	36.22%	3226.7	(3223.9 3229.4)	199,669	8.58%	3249.2	(3245.1 3253.4)	76,884	12.49%
Total [2]			590,105				2,327,114				615,683	

Note: 1. East Asian includes Chinese, Korean, and Japanese;
2. Total includes other racial/ethnic groups that not presented here.

Table 7: Parental and Child Characteristics by Paternal Race/Ethnicity Categories Singleton Births with White Mothers, Death/Birth linked data 2001

White Mothers +	Paternal Race/Ethnicity							
	White	Black	Mexican	Puerto Rican	Central/South American	East Asian [1]	American Indian	Missing
Total n=2,212,425	1,884,947	47,147	52,583	9,912	8,831	3,366	11,096	194,543
Parental features								
Maternal age								
<20	5.99%	13.52%	15.66%	13.92%	9.12%	2.67%	13.64%	28.29%
20-33	77.48%	77.71%	74.95%	76.02%	74.71%	67.68%	76.75%	64.94%
>34	16.53%	8.77%	9.39%	10.06%	16.17%	29.65%	9.62%	6.77%
Maternal education								
Less than high school	2.95%	4.98%	6.76%	5.16%	4.38%	0.98%	5.30%	11.25%
High school	35.06%	54.60%	52.99%	53.07%	37.39%	19.90%	53.06%	65.38%
Some college or beyond	61.99%	40.42%	40.26%	41.78%	58.23%	79.11%	41.64%	23.37%
Married	85.67%	45.27%	66.08%	54.76%	74.44%	89.28%	66.09%	7.29%
Mother was U.S. born	94.08%	95.33%	95.26%	94.83%	89.19%	90.89%	97.60%	97.34%
Number of prenatal care visits	12.07	11.63	11.80	11.41	11.80	12.21	11.55	10.72
Tobacco use during pregnancy								
Yes (among non-missing)	13.11%	23.05%	15.84%	20.49%	9.59%	6.19%	24.67%	61.27%
no (among non-missing)	86.89%	76.95%	84.16%	79.51%	90.41%	93.81%	75.33%	38.73%
missing	7.24%	9.82%	28.44%	7.05%	20.63%	34.25%	10.74%	4.43%
Average cigarettes per day	11.08	10.61	10.02	9.68	9.59	9.81	11.15	11.17
Alcohol use during pregnancy								
Yes (among non-missing)	0.83%	0.85%	0.83%	1.29%	0.88%	0.90%	1.17%	2.03%
no (among non-missing)	99.10%	99.06%	98.85%	98.61%	98.89%	98.62%	98.68%	97.87%
missing	7.42%	10.13%	28.63%	7.23%	20.76%	34.73%	11.33%	4.85%
Average drinks per day	2.15	2.92	2.12	2.87	2.51	1.40	4.06	3.37
Adequacy of care								
adequate	81.41%	72.03%	73.74%	71.08%	75.74%	82.44%	71.76%	60.99%
intermediate	13.14%	18.81%	17.43%	19.58%	16.31%	11.44%	19.67%	24.59%
inadequate	2.39%	4.70%	3.86%	4.42%	3.42%	1.87%	4.47%	9.59%
Paternal age								
<20	2.46%	5.34%	6.37%	6.84%	3.08%	0.89%	5.89%	-
20-33	69.30%	71.93%	75.45%	72.47%	69.81%	55.64%	74.18%	-
>34	28.23%	22.73%	18.19%	20.69%	27.11%	43.46%	19.93%	-
Child features								
Live birth order								
First live born	40.22%	39.90%	39.25%	45.17%	44.88%	45.25%	39.33%	52.97%
Second live born	34.96%	32.22%	32.45%	32.05%	33.59%	33.84%	32.02%	24.63%
Third live born or beyond	24.82%	27.88%	28.31%	22.78%	21.54%	20.92%	28.65%	22.40%
Gestational age (weeks)	38.94	38.91	38.96	39.03	38.96	39.10	38.93	38.83
Male	51.33%	50.62%	51.07%	51.87%	51.51%	50.09%	50.74%	50.93%

Note: 1. East Asian includes Chinese, Korean, and Japanese.

Table 8: Parental/ child characteristics, birth outcomes by paternal race/ethnicity, BEFORE weighting (CA excluded)

Covariates	(Reference) Black (W-B) n=42,839	White (W-W) n=1,759,706	Mexican (W-M) n=37,961	American Indian (W-AI) n=9,990	Puerto Rican (W-PR) n=9,281	Central/South American (W-CSA) n=7,048	Missing (W-UN) n=187,717
Maternal features							
Married	44.51%	85.59%	66.93%	66.69%	53.85%	74.48%	7.32%
Maternal age							
<20	13.90%	6.14%	17.05%	14.02%	14.14%	9.41%	28.51%
20-33	77.95%	77.88%	74.55%	76.83%	76.02%	75.50%	65.01%
>34	8.15%	15.98%	8.39%	9.15%	9.85%	15.10%	6.49%
Maternal education							
Less than high school	5.31%	3.09%	8.31%	5.63%	5.42%	4.95%	11.43%
High school	55.27%	35.51%	53.68%	53.24%	53.29%	37.93%	65.52%
Some college or beyond	39.43%	61.41%	38.00%	41.13%	41.29%	57.12%	23.05%
Mother was U.S. born	95.57%	94.59%	95.16%	97.72%	94.85%	88.70%	97.41%
Number of prenatal care visits	11.58	12.03	11.64	11.49	11.34	11.58	10.72
Adequacy of care							
adequate	71.93%	81.34%	72.88%	71.90%	70.60%	74.67%	61.17%
intermediate	19.14%	13.33%	18.79%	20.09%	19.93%	17.58%	24.71%
inadequate	4.81%	2.44%	4.25%	4.52%	4.62%	3.82%	9.58%
Tobacco use	23.05%	13.11%	15.84%	24.67%	20.50%	9.59%	38.73%
Alcohol use	0.85%	0.83%	0.83%	1.17%	1.29%	0.89%	2.02%
Paternal features							
Paternal age							
<20	5.50%	2.53%	6.80%	6.08%	7.03%	3.26%	-
20-33	72.64%	70.00%	76.78%	74.66%	72.62%	71.03%	-
>34	21.86%	27.47%	16.41%	19.26%	20.35%	25.71%	-
Child features							
Gestational age	38.89	38.93	38.90	38.90	39.02	38.94	38.82
Male	50.72%	51.31%	51.01%	50.77%	51.94%	51.25%	50.93%
Live birth order							
First live born	40.01%	40.07%	39.13%	39.34%	45.17%	44.89%	52.96%
Second live born	32.22%	34.96%	32.38%	32.28%	32.02%	33.73%	24.72%
Third live born or beyond	27.78%	24.97%	28.49%	28.38%	22.81%	21.38%	22.31%
Infant Outcome							
Birth weight	3343.40	3413.34	3335.83	3362.32	3330.46	3372.64	3250.53
LBW rate	6.26%	4.64%	5.65%	5.59%	5.68%	5.35%	8.39%
Apgar score	8.919	8.943	8.917	8.932	8.939	8.934	8.881
Infant mortality (per thousand)	7.07	4.29	4.90	6.01	4.20	5.25	10.23

Table 9: Parental/ child characteristics, birth outcomes by paternal race/ethnicity, AFTER weighting (CA excluded)

Covariates	(Reference) Black (W-B) n=42,839	Wt. White (W-W) ESS=662,700	Wt. Mexican (W-M) ESS=28,249	Wt. American Indian (W-AI) ESS=8,088	Wt. Puerto Rican (W-PR) ESS=8,769	Wt. Central/ South American (W-CSA) ESS=4,506	Wt. Missing (W-UN) ESS=42,719
Maternal features							
Married	44.51%	44.38%	45.20%	46.22%	45.92%	47.41%	44.24%
Maternal age							
<20	13.90%	13.86%	14.42%	15.29%	14.04%	14.76%	14.09%
20-33	77.95%	77.55%	77.17%	76.18%	76.95%	76.21%	77.66%
>34	8.15%	8.59%	8.41%	8.53%	9.02%	9.02%	8.24%
Maternal education							
Less than high school	5.31%	5.41%	5.72%	5.99%	5.75%	5.90%	5.77%
High school	55.27%	55.01%	55.83%	56.04%	55.56%	53.19%	56.10%
Some college or beyond	39.43%	39.59%	38.45%	37.97%	38.69%	40.92%	38.13%
Mother was U.S. born	95.57%	95.55%	95.53%	96.37%	95.40%	95.16%	95.44%
Number of prenatal care visits	11.58	11.22	11.24	11.22	11.19	11.22	11.22
Adequacy of care							
adequate	71.93%	72.18%	71.97%	71.28%	71.44%	71.92%	71.55%
intermediate	19.14%	18.97%	19.49%	20.00%	19.31%	19.16%	23.39%
inadequate	4.81%	4.79%	4.76%	4.72%	4.55%	4.79%	5.06%
Tobacco use	23.05%	22.90%	22.56%	24.59%	22.61%	20.06%	19.34%
Alcohol use	0.85%	0.88%	0.89%	1.08%	1.07%	1.07%	0.98%
Paternal features							
Paternal age							
<20	5.50%	5.64%	5.96%	6.34%	5.97%	5.72%	-
20-33	72.64%	72.66%	73.43%	73.25%	73.39%	74.13%	-
>34	21.86%	21.70%	20.61%	20.41%	20.64%	20.15%	-
Child							
Gestational age	38.89	38.81	38.82	38.83	38.92	38.86	38.79
Male	50.72%	51.29%	51.09%	50.56%	51.59%	51.73%	51.00%
Live birth order							
First live born	40.01%	40.55%	40.41%	41.71%	42.11%	42.93%	40.02%
Second live born	32.22%	31.95%	31.51%	31.34%	31.24%	31.49%	31.76%
Third live born or beyond	27.78%	27.51%	28.08%	26.95%	26.65%	25.58%	28.23%
Infant Outcome							
Birth weight	3343.40	3350.57	3318.64	3359.33	3322.60	3343.44	3315.71
LBW rate	6.26%	6.07%	6.10%	5.46%	5.88%	6.09%	6.85%
Apgar score	8.919	8.927	8.913	8.931	8.939	8.928	8.904
Infant mortality (per thousand)	7.07	6.44	5.41	6.12	4.33	6.25	7.81

Table 10 . Comparisons between B-B and B-W; B-B and W-B. Death/Birth linked data 2001

	B-B	**B-W**	**W-B**
N	300731	9950	40913
Birth weight	reference	61.15	191.20
LBW rate (per hundred)	reference	-2.07	-7.24
Apgar score	reference	0.008	0.051
Infant mortality (per thousand)	reference	-1.85	-5.21

Note:

This table presents the results of comparison between B-B and B-W; B-B and W-B, after controlling for the same set of covariates as in previous Table 8 and Table 9, but covariates are not reported in the table.

B-B: black mother-black father; B-W: black mother-white father; W-B: white mother-black father

Table 11: Early neonatal, late neonatal, and postneonatal mortality rates (per thousand) by racial/ethnic- and sex-specific groups

	White		Black		Mexican	
	girl	boy	girl	boy	girl	boy
Early neonatal mortality rate (per 1000)	1.5	1.9	3.0	4.1	1.5	2.0
Deaths	1,662	2,241	839	1,183	432	618
Total births	1,092,370	1,149,359	279,552	288,465	295,941	307,215
Late neonatal mortality rate (per 1000)	0.6	0.7	1.4	1.4	0.6	0.8
Deaths	633	748	377	396	173	239
Total births	1,090,708	1,147,118	278,713	287,282	295,509	306,597
Post neonatal mortality rate (per 1000)	1.5	2.1	3.6	4.6	1.6	1.8
Deaths	1,637	2,371	992	1,312	485	542
Total births	1,090,075	1,146,370	278,336	286,886	295,336	306,358

Table 12: A schematic for selected measures of birth outcomes
(Those are examined as key independent variables at the next analysis step)

Measurement	Description	Example studies
A. When only birth weight is available		
1. Birth weight	Continuous	
2. LBW	1. LBW: <2,500 g 2. normal: >=2,500 g	
B. When both gestational age and birth weight are available		
3. Birth weight + gestational age	Continuous	
4. LBW + gestational age	Binary variable + continuous	
5. Four-category combination of birth weight and gestational age	1. large-for-gestational age: <37 weeks but >=2500 g 2. term normal birth weight: >=37 weeks and >=2500 g 3. preterm LBW: <37 weeks and <2500 g 4. IUGR: >=37 weeks and <2500 g	CDC 1994
6. Six-category * combinations including FGR **	1. Fully compromised: <37 weeks, FGR<.85, <2,500 g 2. Light preterm: <37 weeks, FGR>=.85, <2,500 g 3. Light IUGR: >=37 weeks, FGR<.85, <2,500 g 4. Heavy preterm: <37 weeks, FGR>=.85, >=2,500 g 5. Heavy IUGR: >=37 weeks, FGR<.85, >=2,500 g 6. Normal: >=37 weeks, FGR>=.85, >=2,500 g	Frisbie et al. 1996; Hummer et al. 1999
7. Standardized gestation-age-specific birth weight	Birth weight is standardized on a z-scale within each gestational age (week), however when the gestational age is less than 38 weeks, two systematic deviations from the Gaussian emerge and therefore special assessment will be needed	Wilcox 1992
C. When Apgar score is also available		
8. Apgar score	Continuous (0-10)	
9. Categorized Apgar score	1. Low: 0-3 2. Medium: 4-6 3. High: 7-10	
10. Categorized Apgar score + birth weight + gestation		
11. Categorized Apgar score + birth weight + gestation		
12. Categorized Apgar score + LBW + gestation		
13. Categorized Apgar score + Six-category of birth weight and gestation		Doyle et al. 2003

Note:
** This classification was originally developed as an eight-category scheme by Frisbie and his colleagues. Hummer et al. (1999) revised it to six-category because two categories (>=37 weeks, FGR>=.85, <2,500 grams) and (<37 weeks, FGR<.85, >=2,500 grams) are found to be very rare cases, if any.*

*** FGR: is calculated by taking the weight of each birth as a ratio to the mean birth weight of an appropriate gestational age-specific (week-by-week) and sex-specific standard (Kramer 1987; Balcazar et al. 1994: 149).*

**** This birth outcome measure will be discussed separately.*

Table 13: Descriptive statistics of covariates and key birth outcome measures for each gender- and race-specific group, death/birth linked data 2001

	White				Black				Mexican			
	Female		Male		Female		Male		Female		Male	
	Mean	std.	Mean	std.	Mean	std.	mean	std.	Mean	std.	Mean	std.
Covariates												
Mother's age												
<20	8.4%		8.4%		19.1%		19.2%		16.6%		16.6%	
between 20 and 34	76.3%		76.3%		70.9%		71.0%		75.0%		75.0%	
>34	15.3%		15.3%		9.9%		9.8%		8.4%		8.4%	
Married	77.1%		77.2%		31.4%		31.2%		59.3%		59.3%	
Mother born in US	94.3%		94.3%		88.7%		88.6%		35.8%		35.9%	
Mother's education												
< high school	3.9%		3.8%		6.0%		6.0%		39.9%		39.8%	
high school graduates	39.0%		39.0%		58.9%		58.8%		43.8%		43.9%	
≥college	57.1%		57.1%		35.1%		35.2%		16.3%		16.3%	
Father unreported	8.4%		8.3%		36.4%		35.7%		12.9%		12.8%	
Birth order risk												
First birth	41.4%		41.6%		38.0%		38.3%		35.9%		36.1%	
Low parity	54.8%		54.6%		51.2%		51.0%		56.1%		56.1%	
High parity	11.6%		11.6%		22.3%		22.0%		20.5%		20.2%	
APNCU												
Inadequate care	7.2%		7.3%		18.2%		18.4%		18.0%		18.2%	
Intermediate care	8.8%		8.5%		9.4%		9.3%		10.5%		10.1%	
Adequate care	38.4%		37.4%		29.3%		28.7%		32.4%		31.4%	
Adequate plus care	45.6%		46.9%		43.1%		43.6%		39.0%		40.3%	
Tobacco use	15.7%		15.7%		9.2%		9.1%		2.4%		2.4%	
Alcohol use	0.9%		0.9%		1.0%		1.0%		0.5%		0.4%	
California	7.1%		7.2%		5.5%		5.5%		37.3%		37.0%	
Key Independent Variables												
Birth weight (100g)	33.39	5.34	33.33	5.64	30.86	6.03	31.96	6.29	33.01	5.21	33.97	5.58
LBW	5.3%		4.5%		12.0%		10.0%		5.2%		4.9%	
Gestational age (wk)	39.01	2.20	38.89	2.25	38.43	2.91	38.36	2.94	39.00	2.35	38.84	2.41
Classification 1												
Preterm LBW	3.1%		3.1%		7.3%		6.9%		2.9%		3.2%	
Large-for-gestation	5.3%		6.4%		8.1%		9.3%		6.7%		7.7%	
IUGR	2.2%		1.5%		4.7%		3.1%		2.2%		1.7%	
Term	89.4%		89.1%		79.9%		80.8%		88.2%		87.4%	
Classification 2												
<37wks, FGR<.85, <2500g	2.2%		2.2%		4.7%		4.8%		2.5%		2.7%	
<37wks, FGR≥.85, <2500g	0.9%		0.9%		2.7%		2.1%		0.4%		0.5%	
≥37wks, FGR<.85, <2500g	2.2%		1.5%		4.7%		3.1%		2.2%		1.7%	
<37wks, FGR≥.85, ≥2500g	5.3%		6.2%		8.1%		9.3%		6.6%		7.5%	
≥37wks, FGR<.85, ≥2500g	8.4%		8.9%		6.1%		7.4%		7.8%		8.5%	
≥37wks, FGR≥.85, ≥2500g	81.0%		80.2%		73.8%		73.4%		80.4%		78.9%	
Apgar score	8.96	0.62	8.93	0.67	8.87	0.77	8.86	0.82	8.94	0.60	8.91	0.64
Low Apgar score	0.2%		0.2%		0.5%		0.6%		0.2%		0.3%	
Medium Apgar score	0.7%		0.9%		1.3%		1.4%		0.6%		0.8%	
High Apgar score	99.1%		98.9%		98.3%		98.0%		99.1%		99.0%	

Table 14: Results of multivariate analysis of early neonatal mortality, white female infants

	model 1 OR	model 2 OR	model 3 OR	model 4 OR	model 5 OR	model 6 OR	model 7 OR	model 8 OR	model 9 OR	model 10 OR	model 11 OR	model 12 OR	model 13 OR
Covariates													
Mother's age (reference group: between 20 and 34)													
<20	1.04	1.07	0.98	0.93	1.03	1.03	1.04	1.00	0.98	0.92	0.89	0.93	0.94
>34	1.00	1.04	1.00	1.00	1.02	1.02	1.00	1.12	1.10	1.06	1.06	1.06	1.06
Married	1.09	1.02	1.11	1.12	1.04	1.05	1.09	0.92	0.93	1.05	1.04	1.01	1.01
Mother born in US	1.09	1.02	1.11	1.08	0.99	0.99	1.09	1.20	1.11	1.19	1.17	1.09	1.10
Mother's education (reference group: high school graduates)													
< high school	1.24 *	1.14	1.27 **	1.23 *	1.16	1.16	1.24 *	1.30	1.25	1.23	1.21	1.19	1.17
≥college	0.88 *	0.83 ***	0.86 **	0.84 ***	0.81 ***	0.82 ***	0.88 *	0.73 ***	0.76 ***	0.86 *	0.85 *	0.85 *	0.87 *
Father unreported	1.19 *	1.28 ***	1.16	1.15	1.25 **	1.25 **	1.19 *	1.01	1.08	0.98	0.97	1.00	1.00
Birth order risk (reference group: Low parity)													
First birth	0.86 **	1.00	0.90	1.01	1.00	0.98	0.86 **	1.06	0.99	0.91	0.96	0.95	0.94
High parity	1.11	1.10	1.11	1.08	1.06	1.06	1.11	1.01	1.03	0.92	0.89	0.88	0.88
APNCU (reference group: Adequate)													
inadequate care	1.26 *	1.79 ***	1.12	0.93	1.36 ***	1.35 ***	1.26 *	1.94 ***	1.17	1.34 *	1.44 **	1.24	1.22
intermediate care	1.23	1.24	1.35 **	1.48 ***	1.31 *	1.29 *	1.23	1.17	2.09 ***	1.37 **	1.25	1.27	1.27
adequate plus care	1.11	1.86 ***	0.96	0.85 *	1.24 ***	1.24 ***	1.11	3.41 ***	3.06 ***	1.32 ***	1.20 *	1.35 ***	1.35 ***
tobacco use	0.69 ***	0.63 ***	0.73 ***	0.77 ***	0.69 ***	0.67 ***	0.69 ***	0.96	0.89	0.73 ***	0.77 **	0.76 ***	0.73 ***
alcohol use	1.12	1.20	1.12	1.08	1.16	1.17	1.12	1.10	1.20	1.20	1.15	1.16	1.15
California	1.14	1.11	1.23 *	1.21 *	1.17	1.18	1.14	-	-	-	-	-	-
Key Independent Variables													
Birth weight (100g)	0.78 ***		0.83 ***							0.88 ***			
LBW		39.80 ***		6.98 ***							5.30 ***		
Gestational age (wk)			0.88 ***	0.73 ***						0.98	0.88 ***		
Preterm LBW					77.47 ***							16.58 ***	
Large-for-gestation					4.26 ***							3.17 ***	
IUGR					16.04 ***							9.14 ***	
Term (ref)					-							-	
<37wks, FGR<.85, <2500g						96.85 ***							20.15 ***
<37wks, FGR≥.85, <2500g						93.58 ***							20.81 ***
≥37wks, FGR<.85, <2500 g						19.96 ***							11.19 ***
<37wks, FGR≥.85, ≥2500g						5.26 ***							3.86 ***
≥37wks, FGR<.85, ≥2500g						3.51 ***							3.04 ***
≥37wks, FGR≥.85, ≥2500g (ref)						-							-
Std. gestation-age-specific birthweight							0.49 ***						
Apgar score								0.38 ***					
Low Apgar score									1254.27 ***	287.46 ***	309.86 ***	413.35 ***	406.01 ***
Medium Apgar score									104.45 ***	26.94 ***	29.38 ***	37.05 ***	36.48 ***
High Apgar score									-	-	-	- -	-
R^2	0.3213	0.2049	0.3272	0.3073	0.2260	0.2297	0.0602	0.4547	0.4337	0.5006	0.4965	0.4889	0.4917

*Note: * indicates significant at the 1% level; ** significant at the 5% level; *** significant at the 1% level (two-tailed test).*

Table 15: Results of multivariate analysis of late neonatal mortality, white female infants

	model 1 OR	model 2 OR	model 3 OR	model 4 OR	model 5 OR	model 6 OR	model 7 OR	model 8 OR	model 9 OR	model 10 OR	model 11 OR	model 12 OR	model 13 OR
Covariates													
Mother's age (reference group: between 20 and 34)													
<20	1.01	1.02	1.00	0.96	1.02	1.03	0.99	1.01	1.01	1.03	1.00	1.03	1.03
>34	1.33 ***	1.35 ***	1.31 **	1.29 **	1.32 **	1.32 **	1.51 ***	1.50 ***	1.52 ***	1.41 ***	1.39 ***	1.39 ***	1.39 ***
married	1.08	1.04	1.06	1.05	1.03	1.04	1.01	0.98	0.96	1.03	1.03	1.01	1.02
usborn	1.13	1.10	1.12	1.10	1.07	1.08	1.14	1.01	0.97	1.04	1.00	0.96	0.97
Mother's education (reference group: high school graduates)													
< high school	1.27	1.22	1.28	1.27	1.22	1.22	1.25	1.36 *	1.30	1.26	1.25	1.22	1.21
≥college	0.85 *	0.80 **	0.84 *	0.81 **	0.80 **	0.81 **	0.77 ***	0.70 ***	0.71 ***	0.83 *	0.79 **	0.79 **	0.81 **
Father unreported	1.21	1.28 *	1.18	1.18	1.24	1.24	1.35 **	1.21	1.24	1.12	1.13	1.16	1.16
Birth order risk (reference group: Low parity)													
firstbirth	1.05	1.19 *	1.06	1.20 *	1.17	1.14	1.26 **	1.23 *	1.21 *	0.99	1.10	1.09	1.05
highparity	1.56 ***	1.56 ***	1.54 ***	1.50 ***	1.51 ***	1.51 ***	1.67 ***	1.66 ***	1.66 ***	1.59 ***	1.54 ***	1.54 ***	1.54 ***
APNCU (reference group: Adequate)													
inadequate care	1.39 **	1.71 ***	1.35 *	1.23	1.50 **	1.50 **	2.25 ***	1.66 ***	1.19	1.19	1.33	1.18	1.16
intermediate care	1.07	1.08	1.12	1.25	1.10	1.09	1.07	1.17	1.85 ***	1.27	1.21	1.28	1.29
adequate plus care	1.13	1.55 ***	1.06	0.97	1.24 *	1.25 *	2.54 ***	2.20 ***	2.23 ***	1.18	1.09	1.26 *	1.26 *
tobacco use	1.12	1.12	1.15	1.27 **	1.18	1.12	1.17	1.52 ***	1.48 ***	1.13	1.25 *	1.19	1.12
alcohol use	0.73	0.76	0.73	0.70	0.75	0.76	0.85	0.71	0.74	0.71	0.68	0.68	0.69
California	1.08	1.05	1.12	1.10	1.07	1.08	0.99	-	-	-	-	-	-
Key Independent Variables													
Birth weight (100g)	0.82 ***		0.84 ***							0.85 ***			
LBW		16.44 ***		5.65 ***							5.70 ***		
Gestational age (wk)			0.95 **	0.80 ***						1.02	0.87 ***		
Preterm LBW					25.23 ***							14.24 ***	
Large-for-gestation					2.76 ***							2.47 ***	
IUGR					10.40 ***							8.76 ***	
Term (ref)					-							-	***
<37wks, FGR<.85, <2500g						33.33 ***							19.41 ***
<37wks, FGR≥.85, <2500g						22.28 ***							12.48 ***
≥37wks, FGR<.85, <2500 g						12.57 ***							10.87 ***
<37wks, FGR≥.85, ≥2500g						3.28 ***							3.00 ***
≥37wks, FGR<.85, ≥2500g						2.88 ***							3.09
≥37wks, FGR≥.85, ≥2500g (ref)						-							-
Std. gestation-age-specific birthweight							0.49 ***						
Apgar score								0.51 ***					***
Low Apgar score									82.55 ***	9.38 ***	13.72 ***	26.73 ***	26.17 ***
Medium Apgar score									30.33 ***	5.73 ***	7.66 ***	11.43 ***	11.25
High Apgar score									-	-	-	-	-
R^2	0.1636	0.1089	0.1635	0.1431	0.1153	0.1200	0.0513	0.1157	0.0984	0.1833	0.1662	0.1571	0.1627

*Note: * indicates significant at the 1% level; ** significant at the 5% level; *** significant at the 1% level (two-tailed test).*

Table 16: Results of multivariate analysis of postneonatal mortality, white female infants

	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8	model 9	model 10	model 11	model 12	model 13
	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR
Covariates													
Mother's age (reference group: between 20 and 34)													
<20	1.68 ***	1.69 ***	1.66 ***	1.65 ***	1.68 ***	1.69 ***	1.68 ***	1.65 ***	1.64 ***	1.64 ***	1.63 ***	1.64 ***	1.64 ***
>34	0.91	0.90	0.90	0.89	0.89	0.90	0.91	0.92	0.93	0.91	0.89	0.89	0.90
married	0.81 ***	0.79 ***	0.81 ***	0.80 ***	0.80 ***	0.81 ***	0.81 ***	0.78 ***	0.78 ***	0.81 ***	0.80 ***	0.80 ***	0.81 ***
usborn	1.07	1.05	1.06	1.04	1.03	1.04	1.07	1.04	1.03	1.05	1.03	1.02	1.03
Mother's education (reference group: high school graduates)													
< high school	1.12	1.12	1.13	1.14	1.13	1.12	1.12	1.25 **	1.23 **	1.19 *	1.20 *	1.19 *	1.18
≥college	0.75 ***	0.71 ***	0.74 ***	0.71 ***	0.72 ***	0.73 ***	0.75 ***	0.69 ***	0.69 ***	0.75 ***	0.73 ***	0.73 ***	0.74 ***
Father unreported	1.13	1.16 *	1.14 *	1.15 *	1.16 *	1.16 *	1.13	1.19 **	1.21 **	1.15 *	1.16 *	1.17 *	1.17 *
Birth order risk (reference group: Low parity)													
firstbirth	0.63 ***	0.68 ***	0.64 ***	0.69 ***	0.68 ***	0.66 ***	0.63 ***	0.68 ***	0.69 ***	0.63 ***	0.67 ***	0.66 ***	0.65 ***
highparity	1.43 ***	1.44 ***	1.43 ***	1.41 ***	1.42 ***	1.42 ***	1.43 ***	1.47 ***	1.46 ***	1.42 ***	1.40 ***	1.40 ***	1.40 ***
APNCU (reference group: Adequate)													
inadequate care	1.47 ***	1.62 ***	1.43 ***	1.41 ***	1.50 ***	1.49 ***	1.47 ***	1.66 ***	1.38 ***	1.39 ***	1.48 ***	1.38 ***	1.36 ***
intermediate care	1.41 ***	1.41 ***	1.45 ***	1.57 ***	1.43 ***	1.41 ***	1.41 ***	1.38 ***	1.72 ***	1.42 ***	1.40 ***	1.42 ***	1.42 ***
adequate plus care	1.10	1.28 ***	1.05	1.01	1.14 *	1.14 **	1.10	1.56 ***	1.59 ***	1.13 *	1.09	1.17 **	1.17 **
tobacco use	1.38 ***	1.52 ***	1.41 ***	1.59 ***	1.55 ***	1.46 ***	1.38 ***	1.80 ***	1.78 ***	1.43 ***	1.59 ***	1.56 ***	1.48 ***
alcohol use	0.98	1.02	0.98	0.96	1.01	1.01	0.98	0.90	0.91	0.84	0.83	0.84	0.84
California	1.08	1.05	1.08	1.06	1.04	1.05	1.08	-	-	-	-	-	-
Key Independent Variables													
Birth weight (100g)	0.87 ***		0.88 ***							0.89 ***			
LBW		6.60 ***		3.81 ***							3.54 ***		
Gestational age (wk)			0.97 ***	0.87 ***						0.99	0.91 ***		
Preterm LBW					9.05 ***							6.47 ***	
Large-for-gestation					1.92 ***							1.89 ***	
IUGR					4.80 ***							4.31 ***	
Term (ref)					-							-	
<37wks, FGR<.85, <2500g						11.58 ***							7.95 ***
<37wks, FGR≥.85, <2500g						7.49 ***							5.69 ***
≥37wks, FGR<.85, <2500 g						5.59 ***							4.91 ***
<37wks, FGR≥.85, ≥2500g						2.19 ***							2.12 ***
≥37wks, FGR<.85, ≥2500g						2.26 ***							2.05 ***
≥37wks, FGR≥.85, ≥2500g (ref)						-							-
Std. gestation-age-specific birthweight							0.60 ***						
Apgar score								0.58 ***					
Low Apgar score									28.61 ***	6.88 ***	9.29 ***	13.30 ***	13.101 ***
Medium Apgar score									13.89 ***	4.91 ***	5.93 ***	7.16 ***	7.0681 ***
High Apgar score									-	-	-	-	-
R^2	0.0854	0.0652	0.0862	0.0743	0.0682	0.0725	0.0468	0.0665	0.0587	0.0956	0.0875	0.0854	0.0886

*Note: * indicates significant at the 10% level (two-tailed test); ** significant at the 5% level (two-tailed test); *** significant at the 1% level.*

Table 17: Results of multivariate analysis of early neonatal mortality, black female infants

	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8	model 9	model 10	model 11	model 12	model 13
	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR
Covariates													
Mother's age (reference group: between 20 and 34)													
<20	1.00	0.88	0.95	0.88	0.85	0.85	0.83	0.93	0.88	0.92	0.90	0.89	0.89
>34	0.96	1.01	0.97	0.97	0.96	0.95	1.26 *	1.37 *	1.33 **	1.26	1.27	1.24	1.25
Married	1.51 ***	1.53 ***	1.48 ***	1.51 ***	1.49 ***	1.49 ***	1.43 ***	1.40 **	1.31 **	1.46 ***	1.45 ***	1.40 ***	1.40 ***
Mother born in US	1.28	1.20	1.27	1.26	1.22	1.22	1.31 *	1.44 *	1.30	1.20	1.19	1.12	1.13
Mother's education (reference group: high school graduates)													
< high school	1.19	1.12	1.16	1.14	1.10	1.10	1.12	1.34	1.21	1.17	1.18	1.19	1.18
≥college	1.06	1.10	1.04	1.07	1.08	1.07	1.04	1.04	1.05	1.04	1.05	1.07	1.06
Father unreported	1.36 ***	1.42 ***	1.30 ***	1.30 ***	1.34 ***	1.34 ***	1.51 ***	1.32 **	1.33 **	1.25 *	1.24 *	1.21 *	1.20
Birth order risk (reference group: Low parity)													
First birth	0.99	1.13	1.01	1.12	1.16	1.13	1.25 **	1.07	1.04	0.94	0.99	1.02	1.01
High parity	0.96	0.91	0.91	0.87	0.86	0.87	0.98	0.89	0.91	0.85	0.84	0.86	0.85
APNCU (reference group: Adequate)													
inadequate care	0.93	1.51 ***	0.83	0.71 **	1.12	1.16	2.41 ***	1.32	1.22	1.17	1.19	1.20	1.21
intermediate care	1.12	1.19	1.16	1.15	1.22	1.22	1.28	1.31	1.42 **	0.82	0.77	0.88	0.90
adequate plus care	0.88	1.91 ***	0.73 **	0.69 ***	1.16	1.18	4.08 ***	2.94 ***	2.67 ***	0.96	0.91	1.15	1.16
tobacco use	1.43	1.63 *	1.37	-	-	-	-	0.76	0.77	0.58 ***	0.57 ***	0.58 ***	0.58 ***
alcohol use	-	-	-	1.44	1.46	1.41	2.27 ***	2.73 ***	2.23 **	2.06 ***	1.92 *	1.91 ***	1.95 *
California	1.20	1.16	1.04	1.05	1.04	1.04	0.99	-	-	-	-	-	-
Key Independent Variables													
Birth weight (100g)	0.78 ***		0.84 ***							0.88 ***			
LBW		31.78 ***		4.60 ***							4.13 ***		
Gestational age (wk)			0.89 ***	0.74 ***						0.97	0.87 ***		
Preterm LBW					57.44 ***							13.80 ***	
Large-for-gestation					1.68 *							1.27	
IUGR					6.97 ***							4.86 ***	
Term (ref)					-							-	
<37wks, FGR<.85, <2500g						74.85 ***							15.40 ***
<37wks, FGR≥.85, <2500g						38.17 ***							11.29 ***
≥37wks, FGR<.85, <2500 g						7.50 ***							4.97 ***
<37wks, FGR≥.85, ≥2500g						1.79 **							1.30
≥37wks, FGR<.85, ≥2500g						2.02 **							1.25
≥37wks, FGR≥.85, ≥2500g (ref)						-							-
Std. gestation-age-specific birthweight							0.53 ***						
Apgar score								0.42 ***					
Low Apgar score									566.93 ***	69.86 ***	87.93 ***	165.10 ***	160.70 ***
Medium Apgar score									61.22 ***	10.55 ***	12.91 ***	20.05 ***	19.65 ***
High Apgar score									-	-	-	-	-
R^2	0.3571	0.1980	0.3651	0.3393	0.2276	0.2328	0.0551	0.4284	0.4122	0.4833	0.4763	0.4599	0.4606

*Note: * indicates significant at the 1% level; ** significant at the 5% level; *** significant at the 1% level (two-tailed test).*

Table 18: Results of multivariate analysis of late neonatal mortality, black female infants

	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8	model 9	model 10	model 11	model 12	model 13
	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR
Covariates													
Mother's age (reference group: between 20 and 34)													
<20	0.96	0.89	0.94	0.89	0.88	0.88	0.85	0.83	0.82	0.88	0.84	0.84	0.83
>34	0.87	0.92	0.87	0.87	0.89	0.88	1.10	1.03	1.02	0.89	0.90	0.90	0.90
Married	1.46 ***	1.45 **	1.46 ***	1.46 **	1.45 **	1.45 **	1.38 **	1.44 **	1.40 **	1.50 **	1.50 **	1.48 **	1.49 **
Mother born in US	1.17	1.16	1.18	1.21	1.18	1.18	1.23	1.43	1.35	1.25	1.28	1.22	1.21
Mother's education (reference group: high school graduates)													
< high school	1.29	1.22	1.30	1.27	1.23	1.23	1.22	1.43	1.33	1.41	1.39	1.38	1.39
≥college	1.14	1.14	1.11	1.12	1.13	1.13	1.09	1.10	1.12	1.15	1.14	1.18	1.18
Father unreported	1.51 ***	1.54 ***	1.51 ***	1.51 ***	1.52 ***	1.52 ***	1.62 ***	1.60 ***	1.57 ***	1.53 ***	1.52 ***	1.51 ***	1.50 ***
Birth order risk (reference group: Low parity)													
First birth	0.81	0.91	0.83	0.92	0.93	0.91	0.98	1.00	0.99	0.83	0.91	0.92	0.90
High parity	1.04	1.01	1.02	0.98	0.99	0.99	1.07	1.01	1.03	0.99	0.96	0.97	0.97
APNCU (reference group: Adequate)													
inadequate care	0.87	1.24	0.80	0.71	1.02	1.04	1.74	1.36	1.35	1.26	1.29	1.29	1.28
intermediate care	1.30	1.36	1.36	1.40	1.39	1.38	1.43	1.35	1.44	0.78	0.73	0.92	0.93
adequate plus care	1.01	1.79 ***	0.90	0.86	1.30	1.32	3.17 ***	2.81 ***	2.71 ***	0.99	0.96	1.35 *	1.37 *
tobacco use	0.88	1.00	-	-	-	-	1.32	1.33	1.34	1.10	1.14	1.11	1.10
alcohol use	-	-	0.89	0.93	0.96	0.93	-	1.17	1.09	0.94	0.92	0.89	0.90
California	1.25	1.19	1.36	1.37	1.34	1.34	1.06	-	-	-	-	-	-
Key Independent Variables													
Birth weight (100g)	0.82 ***		0.86 ***							0.87 ***			
LBW		14.61 ***		3.08 ***							3.04 ***		
Gestational age (wk)			0.91 ***	0.77 ***						0.94 ***	0.81 ***		
Preterm LBW					24.35 ***							13.76 ***	
Large-for-gestation					1.95 ***							1.69 *	
IUGR					5.36 ***							4.77 ***	
Term (ref)					-							-	
<37wks, FGR<.85, <2500g						31.72 ***							17.45 ***
<37wks, FGR≥.85, <2500g						16.82 ***							11.38 ***
≥37wks, FGR<.85, <2500 g						5.80 ***							5.32 ***
<37wks, FGR≥.85, ≥2500g						2.09 ***							1.86 **
≥37wks, FGR<.85, ≥2500g						2.09 **							2.45 ***
≥37wks, FGR≥.85, ≥2500g (ref)						-							-
Std. gestation-age-specific birthweight							0.57 ***						
Apgar score								0.54 ***					
Low Apgar score									57.61 ***	3.51 ***	4.75 ***	16.73 ***	16.02 ***
Medium Apgar score									29.09 ***	3.19 ***	4.29 ***	9.55 ***	9.22 ***
High Apgar score									-	-	-	-	-
R^2	0.2248	0.1193	0.2296	0.2053	0.1351	0.1391	0.0362	0.1352	0.1298	0.2520	0.2326	0.1953	0.1982

*Note: * indicates significant at the 1% level; ** significant at the 5% level; *** significant at the 1% level (two-tailed test).*

Table 19: Results of multivariate analysis of postneonatal mortality, black female infants

	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8	model 9	model 10	model 11	model 12	model 13
	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR
Covariates													
Mother's age (reference group: between 20 and 34)													
<20	1.21 *	1.20 *	1.20 *	1.18 *	1.19 *	1.19 *	1.18 *	1.32 ***	1.30 **	1.29 **	1.28 **	1.28 **	1.28 **
>34	0.82	0.84	0.82	0.81 *	0.83	0.83	0.94	0.83	0.84	0.77 **	0.76 **	0.77 **	0.77 **
Married	0.95	0.92	0.94	0.93	0.92	0.92	0.90	0.95	0.94	0.99	0.98	0.97	0.98
Mother born in US	1.31 *	1.37 **	1.33 *	1.38 **	1.37 **	1.36 **	1.40 **	1.32 *	1.30 *	1.21	1.25	1.23	1.22
Mother's education (reference group: high school graduates)													
< high school	1.17	1.16	1.18	1.17	1.16	1.16	1.15	1.18	1.15	1.17	1.17	1.17	1.17
≥college	0.92	0.90	0.91	0.89	0.90	0.90	0.89	0.93	0.93	0.97	0.95	0.96	0.97
Father unreported	1.33 ***	1.35 ***	1.32 ***	1.32 ***	1.33 ***	1.33 ***	1.38 ***	1.34 ***	1.35 ***	1.30 ***	1.30 ***	1.30 ***	1.30 ***
Birth order risk (reference group: Low parity)													
First birth	0.74 ***	0.77 ***	0.75 ***	0.79 **	0.78 ***	0.77 ***	0.79 ***	0.79 **	0.81 **	0.75 ***	0.79 **	0.78 **	0.77 ***
High parity	1.58 ***	1.57 ***	1.56 ***	1.54 ***	1.54 ***	1.55 ***	1.62 ***	1.58 ***	1.59 ***	1.55 ***	1.53 ***	1.54 ***	1.54 ***
APNCU (reference group: Adequate)													
inadequate care	1.09	1.23 **	1.02	0.98	1.14	1.14	1.45 ***	1.23 *	0.73 *	0.71 **	0.73 *	0.71 **	0.71 **
intermediate care	0.82	0.83	0.85	0.88	0.84	0.83	0.85	0.72 *	1.27 **	1.00	0.98	1.06	1.06
adequate plus care	0.92	1.14	0.82 **	0.78 ***	0.99	1.00	1.53 ***	1.35 ***	1.36 ***	0.87	0.84 *	0.99	1.00
tobacco use	1.05	1.18	1.07	-	-	-	1.39	1.85	1.86 ***	1.62 ***	1.70 ***	1.67 ***	1.65 ***
alcohol use	-	-	-	1.12	1.16	1.13	-	1.06	1.03	0.90	0.89	0.89	0.88
California	1.01	0.97	0.98	0.98	0.96	0.96	0.93	-	-	-	-	-	-
Key Independent Variables													
Birth weight (100g)	0.88 ***		0.91 ***							0.92 ***			
LBW		5.14 ***		2.32 ***							2.22 ***		
Gestational age (wk)			0.93 ***	0.85 ***						0.96 ***	0.89 ***		
Preterm LBW					7.17 ***							4.74 ***	
Large-for-gestation					1.43 ***							1.32 *	
IUGR					3.01 ***							2.68 ***	
Term (ref)					-							-	
<37wks, FGR<.85, <2500g						8.58 ***							5.46 ***
<37wks, FGR≥.85, <2500g						6.09 ***							4.40 ***
≥37wks, FGR<.85, <2500 g						3.21 ***							2.87 ***
<37wks, FGR≥.85, ≥2500g						1.52 ***							1.40 **
≥37wks, FGR<.85, ≥2500g						1.80 ***							1.78 ***
≥37wks, FGR≥.85, ≥2500g (ref)						-							-
Std. gestation-age-specific birthweight							0.69 ***						
Apgar score								0.63 ***					
Low Apgar score									17.51 ***	3.37 ***	4.43 ***	8.28 ***	8.08 ***
Medium Apgar score									10.31 ***	2.91 ***	3.62 ***	5.23 ***	5.13 ***
High Apgar score									-	-	-	-	-
R^2	0.0900	0.0563	0.0932	0.0818	0.0613	0.0633	0.0272	0.0618	0.0548	0.0968	0.0890	0.0795	0.0811

*Note: * indicates significant at the 1% level; ** significant at the 5% level; *** significant at the 1% level (two-tailed test).*

Table 20: Results of multivariate analysis of early neonatal mortality, Mexican female infants

	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8	model 9	model 10	model 11	model 12	model 13
	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR
Covariates													
Mother's age (reference group: between 20 and 34)													
<20	0.84	0.81	0.81	0.77	0.79	0.79	0.81	0.52	0.68	0.59	0.62	0.62	0.62
>34	0.76	0.86	0.67 *	0.69 *	0.76	0.76	1.09	0.77	0.66	0.68	0.66	0.69	0.68
Married	1.34 **	1.30 **	1.37 **	1.37 **	1.34 **	1.34 **	1.27 *	1.41	1.24	1.32	1.30	1.24	1.26
Mother born in US	0.99	0.99	1.03	1.02	1.01	1.01	1.07	1.05	0.87	0.72	0.71	0.75	0.76
Mother's education (reference group: high school graduates)													
< high school	1.16	1.14	1.23	1.21	1.21	1.21	1.16	1.05	1.04	0.98	0.97	0.98	1.00
≥college	0.94	0.91	0.99	0.98	0.95	0.96	0.88	0.96	1.02	1.16	1.25	1.22	1.20
Father unreported	1.47 **	1.52 **	1.46 **	1.40 *	1.50 **	1.47 **	1.65 ***	1.71	1.53	1.57	1.51	1.49	1.43
Birth order risk (reference group: Low parity)													
First birth	0.78 *	0.87	0.82	0.89	0.91	0.90	0.98	1.04	0.86	0.84	0.89	0.86	0.85
High parity	1.10	1.09	1.06	1.00	1.03	1.02	1.16	2.12 **	1.80 **	1.86 **	1.87 **	1.77 **	1.72 *
APNCU (reference group: Adequate)													
inadequate care	1.41 *	1.55 **	1.31	1.10	1.18	1.16	2.27 ***	2.76 ***	0.42	0.56	0.57	0.60	0.57
intermediate care	0.73	0.69	0.80	0.84	0.73	0.73	0.74	0.44	2.42 ***	1.92 *	1.83 *	1.61	1.57
adequate plus care	1.19	1.74 ***	0.97	0.83	1.06	1.05	3.46 ***	2.61 ***	2.53 ***	1.30	1.18	1.05	1.04
tobacco use	-	-	-	-	-	-	-	0.84	0.87	0.59	0.62	0.62	0.61
alcohol use	0.75	0.68	0.75	0.74	0.72	0.73	0.81	2.18	2.55	2.29	2.33	2.51	2.59
California	1.11	1.17	1.15	1.16	1.20	1.20	1.07	-	-	-	-	-	-
Key Independent Variables													
Birth weight (100g)	0.79 ***		0.84 ***							0.90 ***			
LBW		43.28 ***		10.16 ***							5.82 ***		
Gestational age (wk)			0.88 ***	0.77 ***						1.00	0.94 **		
Preterm LBW					101.55 ***							15.82 ***	
Large-for-gestation					6.07 ***							5.03 ***	
IUGR					20.11 ***							9.85 ***	
Term (ref)					-							-	
<37wks, FGR<.85, <2500g						113.29 ***							19.55 ***
<37wks, FGR≥.85, <2500g						173.69 ***							27.45 ***
≥37wks, FGR<.85, <2500g						24.03 ***							12.89 ***
<37wks, FGR≥.85, ≥2500g						7.38 ***							6.61 ***
≥37wks, FGR<.85, ≥2500g						3.22 ***							4.02 ***
≥37wks, FGR≥.85, ≥2500g (ref)						-							-
Std. gestation-age-specific birthweight							0.47 ***						
Apgar score								0.37 ***					
Low Apgar score									1485.81 ***	464.84 ***	487.55 ***	488.32 ***	472.14 ***
Medium Apgar score									104.96 ***	37.20 ***	35.04 ***	35.68 ***	34.635 ***
High Apgar score									-	-	-	-	-
R^2	0.2926	0.2091	0.3042	0.2951	0.2370	0.2406	0.0610	0.4729	0.4622	0.4969	0.4990	0.5060	0.5106

*Note: * indicates significant at the 1% level; ** significant at the 5% level; *** significant at the 1% level (two-tailed test).*

Table 21: Results of multivariate analysis of late neonatal mortality, Mexican female infants

	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8	model 9	model 10	model 11	model 12	model 13
	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR
Covariates													
Mother's age (reference group: between 20 and 34)													
<20	1.06	1.03	1.08	1.03	1.05	1.05	1.03	1.21	1.25	1.22	1.21	1.22	1.22
>34	0.65	0.72	0.59	0.61	0.65	0.65	0.87	1.03	0.99	0.86	0.87	0.87	0.87
Married	0.88	0.85	0.87	0.87	0.85	0.85	0.84	1.30	1.27	1.36	1.34	1.36	1.35
Mother born in US	0.87	0.88	0.88	0.89	0.89	0.89	0.92	1.56	1.44	1.35	1.33	1.34	1.34
Mother's education (reference group: high school graduates)													
< high school	0.92	0.91	0.95	0.94	0.94	0.94	0.92	1.15	1.16	1.14	1.12	1.13	1.13
≥college	1.17	1.14	1.20	1.18	1.15	1.16	1.12	0.78	0.88	0.90	0.87	0.93	0.92
Father unreported	1.27	1.29	1.32	1.28	1.34	1.34	1.36	1.46	1.48	1.42	1.38	1.45	1.44
Birth order risk (reference group: Low parity)													
First birth	1.09	1.20	1.05	1.15	1.16	1.15	1.27	1.30	1.24	1.01	1.08	1.08	1.09
High parity	1.36	1.36	1.35	1.28	1.34	1.34	1.44	0.85	0.81	0.76	0.74	0.74	0.74
APNCU (reference group: Adequate)													
inadequate care	1.02	1.12	0.91	0.81	0.92	0.91	1.47	2.15 *	0.56	0.58	0.61	0.56	0.56
intermediate care	0.99	0.97	1.03	1.11	1.00	1.00	1.00	0.57	2.24 **	1.53	1.42	1.51	1.50
adequate plus care	1.11	1.51 *	1.02	0.90	1.19	1.19	2.56 ***	2.81 ***	2.88 ***	1.32	1.21	1.39	1.38
tobacco use	-	-	-	-	-	-	-	4.07 ***	4.01 ***	2.89 **	3.17 ***	3.13 ***	3.16 ***
alcohol use	-	-	-	-	-	-	-	-	-	-	-	-	
California	1.22	1.24	1.23	1.25	1.25	1.25	1.16	-	-	-	-	-	-
Key Independent Variables													
Birth weight (100g)	0.81 ***		0.83 ***							0.86 ***			
LBW		22.95 ***		8.31 ***							5.57 ***		
Gestational age (wk)			0.95	0.81 ***						0.93	0.84 ***		
Preterm LBW					38.10 ***							21.24 ***	
Large-for-gestation					2.03 *							2.29	
IUGR					12.12 ***							5.21 ***	
Term (ref)					-							-	
<37wks, FGR<.85, <2500g						37.95 ***							20.38 ***
<37wks, FGR≥.85, <2500g						46.43 ***							24.54 ***
≥37wks, FGR<.85, <2500g						12.43 ***							5.14 ***
<37wks, FGR≥.85, ≥2500g						2.12 **							2.30
≥37wks, FGR<.85, ≥2500g						1.26 *							0.84
≥37wks, FGR≥.85, ≥2500g (ref)						-							-
Std. gestation-age-specific birthweight							0.47 ***						
Apgar score								0.51 ***					
Low Apgar score									74.26 ***	4.19	6.91 **	17.79 ***	17.87 ***
Medium Apgar score									25.17 ***	2.76	3.76 **	7.18 ***	7.12 ***
High Apgar score									-	-	-	-	-
R^2	0.1850	0.1284	0.1897	0.1720	0.1405	0.1408	0.0516	0.1295	0.1025	0.2010	0.1919	0.1791	0.1794

*Note: * indicates significant at the 1% level; ** significant at the 5% level; *** significant at the 1% level (two-tailed test).*

Table 22: Results of multivariate analysis of postneonatal mortality, Mexican female infants

	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8	model 9	model 10	model 11	model 12	model 13
	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR
Covariates													
Mother's age (reference group: between 20 and 34)													
<20	1.37 **	1.39 **	1.37 **	1.38 **	1.39 **	1.39 **	1.36 **	0.82	0.86	0.84	0.85	0.85	0.85
>34	1.12	1.14	1.13	1.12	1.15	1.15	1.29	0.91	0.90	0.82	0.80	0.81	0.81
Married	0.83 *	0.81 *	0.83 *	0.82 *	0.81 *	0.82	0.81 *	0.80	0.79	0.82	0.80	0.80	0.80
Mother born in US	1.17	1.19	1.21 *	1.23 *	1.23 *	1.22 *	1.21 *	1.36	1.30	1.25	1.26	1.26	1.25
Mother's education (reference group: high school graduates)													
< high school	0.96	0.96	0.96	0.96	0.95	0.95	0.97	0.85	0.85	0.87	0.86	0.86	0.86
≥college	0.97	0.95	0.97	0.96	0.95	0.96	0.95	0.81	0.86	0.93	0.91	0.91	0.91
Father unreported	1.56 ***	1.59 ***	1.55 ***	1.55 ***	1.57 ***	1.57 ***	1.63 ***	2.00 ***	2.02 ***	1.98 ***	1.94	1.95 ***	1.94 ***
Birth order risk (reference group: Low parity)													
First birth	0.65 ***	0.69 ***	0.66 ***	0.71 ***	0.70 ***	0.70 ***	0.69 ***	0.86	0.83	0.71 *	0.75	0.75	0.75
High parity	1.20	1.19	1.21	1.18	1.19	1.20	1.23 *	1.45 *	1.41 *	1.38	1.35	1.35	1.35
APNCU (reference group: Adequate)													
inadequate care	1.11	1.17	1.12	1.08	1.14	1.14	1.34 **	1.66 **	1.44	1.41	1.46	1.40	1.40
intermediate care	1.15	1.14	1.17	1.24	1.15	1.15	1.15	1.45	1.68 **	1.41	1.37	1.36	1.36
adequate plus care	1.10	1.25 *	1.10	1.02	1.17	1.18	1.68 ***	1.63 **	1.65 **	1.16	1.09	1.13	1.14
tobacco use	-	-	-	-	-	-	-	1.80 *	1.82 *	1.41	1.44	1.42	1.41
alcohol use	2.16	2.19	2.18	2.27	2.26	2.24	2.31	2.07	2.05	1.95	2.05	2.09	2.10
California	1.16	1.15	1.22 *	1.21 *	1.20 *	1.21 *	1.13	-	-	-	-	-	-
Key Independent Variables													
Birth weight (100g)	0.86 ***		0.87 ***							0.88 ***			
LBW		9.32 ***		5.93 ***							5.78		
Gestational age (wk)			0.98	0.89 ***						1.02	0.95		
Preterm LBW					12.17 ***							8.29 ***	
Large-for-gestation					1.46 **							1.68 *	
IUGR					7.17 ***							6.88 ***	
Term (ref)					-							-	
<37wks, FGR<.85, <2500g						12.17 ***							8.33 ***
<37wks, FGR≥.85, <2500g						14.29 ***							10.56 ***
≥37wks, FGR<.85, <2500g						7.36 ***							7.20 ***
<37wks, FGR≥.85, ≥2500g						1.42 *							1.65
≥37wks, FGR<.85, ≥2500g						1.37							1.57
≥37wks, FGR≥.85, ≥2500g (ref)						-							-
Std. gestation-age-specific birthweight							0.56 ***						
Apgar score								0.55 ***					
Low Apgar score									35.24 ***	7.78 ***	11.81	15.0925 ***	15.24 ***
Medium Apgar score									23.85 ***	7.56 ***	8.96	10.4593 ***	10.39 ***
High Apgar score									-	-	-	-	-
R^2	0.0846	0.0652	0.0859	0.0747	0.0686	0.0689	0.0370	0.0760	0.0702	0.1136	0.1102	0.1096	0.1103

*Note: * indicates significant at the 1% level; ** significant at the 5% level; *** significant at the 1% level (two-tailed test).*

Table 23: Results of multivariate analysis of early neonatal mortality, white male infants

	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8	model 9	model 10	model 11	model 12	model 13
	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR
Covariates													
Mother's age (reference group: between 20 and 34)													
<20	1.14	1.19 **	1.10	1.07	1.19 **	1.19 **	1.14	1.05	1.11	0.91	0.91	0.97	0.98
>34	1.14 **	1.19 ***	1.13 *	1.12 *	1.18 ***	1.18 ***	1.42 ***	1.38 ***	1.34 ***	1.18 *	1.18 *	1.20 **	1.20 **
Married	1.10	1.04	1.10	1.10	1.05	1.06	0.95	0.92	0.96	1.03	1.02	1.00	1.01
Mother born in US	1.28 **	1.22 *	1.28 **	1.24 *	1.19	1.19	1.32 **	1.32	1.20	1.33 *	1.29	1.22	1.22
Mother's education (reference group: high school graduates)													
< high school	1.12	1.10	1.13	1.13	1.12	1.11	1.18 *	1.39 **	1.34 **	1.31 **	1.29 *	1.30 **	1.28 *
≥college	1.02	0.96	0.99	0.95	0.94	0.95	0.84 ***	0.87 **	0.88 **	0.99	0.96	0.98	0.98
Father unreported	1.17 **	1.26 ***	1.15 *	1.17 *	1.23 ***	1.22 **	1.37 ***	1.15	1.20 *	1.07	1.09	1.09	1.09
Birth order risk (reference group: Low parity)													
First birth	0.80 ***	0.94	0.84 ***	0.94	0.93	0.92	1.13 ***	1.02	0.96	0.80 ***	0.88 *	0.87 **	0.85 **
High parity	1.27 ***	1.30 ***	1.26 ***	1.25 ***	1.26 ***	1.26 ***	1.45 ***	1.36 ***	1.34 ***	1.29 **	1.27 **	1.23 **	1.23 **
APNCU (reference group: Adequate)													
inadequate care	1.32 ***	1.79 ***	1.18 *	1.05	1.42 ***	1.39 ***	2.89 ***	1.95 ***	1.23	1.28 *	1.45 ***	1.27 *	1.24
intermediate care	1.18	1.23 *	1.31 **	1.46 ***	1.29 **	1.27 **	1.28 **	1.22	2.03 ***	1.14	1.10	1.10	1.08
adequate plus care	1.03	1.67 ***	0.85 **	0.79 ***	1.14 *	1.13 *	3.54 ***	2.83 ***	2.70 ***	1.09	1.03	1.10	1.09
tobacco use	-	-	-	-	-	-	-	1.05	1.03	0.75 ***	0.81 ***	0.79 ***	0.77 ***
alcohol use	1.29	1.28	1.32	1.28	1.32	1.31	1.49 ***	1.03	1.14	1.22	1.19	1.20	1.20
California	0.91	0.89	0.90	0.88	0.89	0.89	0.80 ***	-	-	-	-	-	-
Key Independent Variables													
Birth weight (100g)	1.00 ***		1.00 ***							1.00 ***			
LBW		40.59 ***		6.33 ***							5.15 ***		
Gestational age (wk)			0.87 ***	0.74 ***						0.98 *	0.87 ***		
Preterm LBW					74.48 ***							18.72 ***	
Large-for-gestation					4.36 ***							3.60 ***	
IUGR					17.43 ***							10.34 ***	
Term (ref)													
<37wks, FGR<.85, <2500g						82.98 ***							20.76 ***
<37wks, FGR≥.85, <2500g						110.24 ***							25.66 ***
≥37wks, FGR<.85, <2500g						21.22 ***							12.21 ***
<37wks, FGR≥.85, ≥2500g						5.40 ***							4.37 ***
≥37wks, FGR<.85, ≥2500g						3.05 ***							2.46 ***
≥37wks, FGR≥.85, ≥2500g (ref)													
Std. gestation-age-specific birthweight							0.53 ***						
Apgar score								0.38 ***					
Low Apgar score									980.27 ***	228.99 ***	250.10	327.47 ***	321.65 ***
Medium Apgar score									74.77 ***	19.39 ***	21.53	26.53 ***	26.02 ***
High Apgar score									-	-	-	-	-
R^2	0.3184	0.2106	0.3281	0.3064	0.2294	0.2333	0.0555	0.4543	0.4270	0.4992	0.4919	0.4851	0.4874

*Note: * indicates significant at the 1% level; ** significant at the 5% level; *** significant at the 1% level (two-tailed test).*

Table 24: Results of multivariate analysis of late neonatal mortality, white male infants

	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8	model 9	model 10	model 11	model 12	model 13
	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR
Covariates													
Mother's age (reference group: between 20 and 34)													
<20	1.28 *	1.29 **	1.24 *	1.21	1.28 *	1.29 **	1.26	1.40 **	1.42 **	1.33 **	1.29 *	1.35 **	1.36 **
>34	0.92	0.93	0.91	0.89	0.92	0.92	1.06	1.01	1.01	0.90	0.89	0.91	0.91
Married	0.94	0.89	0.93	0.91	0.89	0.90	0.84	0.87	0.88	0.96	0.94	0.93	0.93
Mother born in US	1.15	1.13	1.16	1.14	1.12	1.12	1.19	1.26	1.16	1.22	1.19	1.15	1.16
Mother's education (reference group: high school graduates)													
< high school	1.24	1.24	1.26	1.27	1.25	1.24	1.31 *	1.31	1.27	1.20	1.21	1.21	1.21
≥college	0.90	0.83 **	0.87	0.83 **	0.82 **	0.83 **	0.77 ***	0.77 **	0.78 **	0.87	0.84	0.84	0.85
Father unreported	1.15	1.21	1.15	1.17	1.21	1.20	1.29 **	1.25	1.27 *	1.16	1.18	1.20	1.19
Birth order risk (reference group: Low parity)													
First birth	0.74 ***	0.84 *	0.77 ***	0.86 *	0.84 **	0.82 **	0.94	0.95	0.91	0.76 ***	0.83 *	0.81 **	0.79 **
High parity	1.13	1.15	1.11	1.11	1.13	1.13	1.25 *	1.26 *	1.27 *	1.15	1.14	1.14	1.14
APNCU (reference group: Adequate)													
inadequate care	1.07	1.33 *	0.98	0.92	1.18	1.18	1.81 ***	1.64 ***	1.00	1.01	1.14	1.01	0.99
intermediate care	0.99	1.04	1.08	1.23	1.09	1.07	1.06	0.98	1.75 ***	1.07	1.01	1.17	1.18
adequate plus care	1.10	1.55 ***	0.95	0.91	1.23 **	1.25	2.57 ***	2.25 ***	2.26 ***	1.03	0.99	1.22 *	1.23 *
tobacco use	-	-	-	-	-	-	-	1.38 ***	1.38 ***	1.06	1.15	1.12	1.07
alcohol use	1.36	1.39	1.37	1.34	1.44	1.43	1.56	1.23	1.38	1.39	1.29	1.36	1.36
California	1.08	1.04	1.17	1.14	1.13	1.14	0.97	-	-	-	-	-	-
Key Independent Variables													
Birth weight (100g)	1.00 ***		1.00 ***							1.00 ***			
LBW		19.33 ***		4.47 ***							4.12 ***		
Gestational age (wk)			0.89 ***	0.77 ***						0.93 ***	0.82 ***		
Preterm LBW					29.94 ***							17.29 ***	
Large-for-gestation					2.09 ***							1.96 ***	
IUGR					6.12 ***							4.90 ***	
Term (ref)					-							-	
<37wks, FGR<.85, <2500g						34.56 ***							20.40 ***
<37wks, FGR≥.85, <2500g						30.55 ***							16.99 ***
≥37wks, FGR<.85, <2500g						6.88 ***							5.54 ***
<37wks, FGR≥.85, ≥2500g						2.25 ***							2.09 ***
≥37wks, FGR<.85, ≥2500g						2.18 ***							2.15 ***
≥37wks, FGR≥.85, ≥2500g (ref)						-							-
Std. gestation-age-specific birthweight							0.60 ***						
Apgar score								0.52 ***					
Low Apgar score									53.18 ***	5.27 ***	6.57 ***	16.20 ***	16.15 ***
Medium Apgar score									30.86 ***	5.22 ***	6.38 ***	10.53 ***	10.49 ***
High Apgar score									-	-	-	-	-
R^2	0.2414	0.1528	0.2422	0.2208	0.2208	0.1680	0.0340	0.0451	0.1290	0.1127	0.2500	0.2308	0.1996

*Note: * indicates significant at the 1% level; ** significant at the 5% level; *** significant at the 1% level (two-tailed test).*

Table 25: Results of multivariate analysis of postneonatal mortality, white male infants

	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8	model 9	model 10	model 11	model 12	model 13
	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR
Covariates													
Mother's age (reference group: between 20 and 34)													
<20	1.36 ***	1.33 ***	1.34 ***	1.31 ***	1.30 ***	1.30 ***	1.30 ***	1.39 ***	1.37 ***	1.38 ***	1.36 ***	1.35 ***	1.35 ***
>34	0.71 ***	0.73 ***	0.71 ***	0.71 ***	0.72 ***	0.72 ***	0.83	0.79 *	0.81 *	0.73 **	0.73 ***	0.73 **	0.74 **
Married	0.92	0.91	0.92	0.91	0.92	0.92	0.90	0.94	0.95	0.98	0.97	0.98	0.98
Mother born in US	1.48 ***	1.55 ***	1.52 ***	1.58 ***	1.58 ***	1.56 ***	1.58 ***	1.60 ***	1.63 ***	1.49 ***	1.54 ***	1.54 ***	1.53 ***
Mother's education (reference group: high school graduates)													
< high school	1.09	1.10	1.10	1.10	1.10	1.10	1.15	1.16	1.15	1.10	1.10	1.11	1.11
≥college	0.89	0.86 **	0.88	0.86 **	0.86 **	0.86 **	0.84 **	0.84 **	0.83 **	0.88	0.87 *	0.87 *	0.87 *
Father unreported	1.10	1.13	1.09	1.09	1.13 *	1.13 *	1.16 **	1.13	1.14 *	1.08	1.08	1.10	1.10
Birth order risk (reference group: Low parity)													
First birth	0.75 ***	0.80 ***	0.77 ***	0.82 **	0.82	0.82 ***	0.82 **	0.81 **	0.82 **	0.75 ***	0.80 ***	0.79 ***	0.78 ***
High parity	1.28 ***	1.27 ***	1.26 ***	1.24 ***	1.26 ***	1.26 ***	1.32 ***	1.31 ***	1.30 ***	1.26 ***	1.24 ***	1.26 ***	1.26 ***
APNCU (reference group: Adequate)													
inadequate care	1.23 **	1.39 ***	1.17	1.11	1.29 ***	1.29 ***	1.71 ***	1.56 ***	1.24 *	1.25 *	1.31 **	1.24 *	1.23
intermediate care	1.25 *	1.27 *	1.30 **	1.37 ***	1.28 **	1.28 **	1.29 **	1.23	1.61 ***	1.19 *	1.15	1.28 **	1.28 **
adequate plus care	1.00	1.23 ***	0.90	0.86	1.08	1.09	1.78 ***	1.56 ***	1.59 ***	0.94	0.90	1.09	1.09
tobacco use	-	-	-	-	-	-	-	1.48 ***	1.48 ***	1.29 ***	1.35 ***	1.32 ***	1.30 ***
alcohol use	1.20	1.28	1.23	1.30	1.29	1.28	1.55 **	1.26	1.27	1.01	1.04	1.05	1.04
California	0.94	0.92	0.88	0.88	0.86	0.86	0.89	-	-	-	-	-	-
Key Independent Variables													
Birth weight (100g)	0.87 ***		0.90 ***							0.91 ***			
LBW		7.25 ***		3.12 ***							2.89 ***		
Gestational age (wk)			0.94 ***	0.85 ***						0.95 ***	0.88 ***		
Preterm LBW					9.60 ***							6.70 ***	
Large-for-gestation					1.32 **							1.23 *	
IUGR					4.05 ***							3.57 ***	
Term (ref)					-							-	
<37wks, FGR<.85, <2500g						10.68 ***							7.51 ***
<37wks, FGR≥.85, <2500g						8.83 ***							6.13 ***
≥37wks, FGR<.85, <2500g						4.27 ***							3.78 ***
<37wks, FGR≥.85, ≥2500g						1.39 ***							1.29 **
≥37wks, FGR<.85, ≥2500g						1.55 ***							1.57 ***
≥37wks, FGR≥.85, ≥2500g (ref)						-							-
Std. gestation-age-specific birthweight							0.64 ***						
Apgar score								0.61 ***					
Low Apgar score									17.82 ***	2.90 ***	3.79 ***	7.23 ***	7.16 ***
Medium Apgar score									11.35 ***	2.70 ***	3.31 ***	4.86 ***	4.85 ***
High Apgar score									-	-	-	-	-
R^2	0.1082	0.0742	0.1117	0.0995	0.0792	0.0802	0.0475	0.0662	0.0573	0.1194	0.1102	0.0983	0.0994

*Note: * indicates significant at the 1% level; ** significant at the 5% level; *** significant at the 1% level (two-tailed test).*

Table 26: Results of multivariate analysis of early neonatal mortality, black male infants

	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8	model 9	model 10	model 11	model 12	model 13
	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR
Covariates													
Mother's age (reference group: between 20 and 34)													
<20	1.22 **	1.06	1.18	1.10	1.03	1.03	1.00	1.11	1.05	1.10	1.06	1.03	1.03
>34	0.97	1.02	1.00	1.02	1.01	1.01	1.30 **	1.08	1.09	1.05	1.06	1.05	1.05
Married	1.04	1.11	1.03	1.06	1.11	1.11	1.06	0.91	0.95	0.90	0.91	0.93	0.93
Mother born in US	0.93	0.93	0.94	0.94	0.94	0.94	1.03	0.88	0.91	0.82	0.84	0.82	0.82
Mother's education (reference group: high school graduates)													
< high school	1.08	1.10	1.07	1.07	1.07	1.08	1.19	1.20	1.17	1.11	1.11	1.14	1.13
≥college	1.12	1.10	1.10	1.09	1.09	1.09	1.01	1.16	1.13	1.17	1.16	1.19 *	1.20 *
Father unreported	1.13	1.24 ***	1.08	1.06	1.22 **	1.22 **	1.33 ***	1.20 *	1.21 **	1.04	1.04	1.08	1.07
Birth order risk (reference group: Low parity)													
First birth	0.87	1.02	0.89	0.97	1.06	1.05	1.16 *	1.07	1.01	0.86	0.92	0.96	0.95
High parity	1.13	1.04	1.11	1.07	1.02	1.02	1.13	1.26 *	1.19	1.13	1.11	1.11	1.11
APNCU (reference group: Adequate)													
inadequate care	1.03	1.55 ***	0.89	0.75 *	1.16	1.17	2.63 ***	1.62 ***	1.26	1.41	1.49 *	1.47 *	1.46 *
intermediate care	1.23	1.30	1.31	1.39 *	1.35	1.35	1.43 *	1.23	1.70 ***	1.01	0.92	1.03	1.04
adequate plus care	1.04	2.04 ***	0.86	0.80 *	1.29 **	1.30 **	4.70 ***	3.13 ***	2.97 ***	1.25	1.14	1.35 **	1.36 **
tobacco use	-	-	-	-	-	-	-	1.10	1.05	0.92	0.94	0.90	0.90
alcohol use	0.72	0.73	0.79	0.84	0.74	0.74	1.07	0.72	0.63	0.51	0.54	0.56	0.55
California	0.91	0.92	0.94	0.95	0.92	0.93	0.83	-	-	-	-	-	-
Key Independent Variables													
Birth weight (100g)	0.79 ***		0.85 ***							0.89 ***			
LBW		39.35 ***		4.60 ***							3.80 ***		
Gestational age (wk)			0.87 ***	0.74 ***						0.96 **	0.87 ***		
Preterm LBW					71.15 ***							15.63 ***	
Large-for-gestation					2.80 ***							2.70 ***	
IUGR					9.04 ***							5.63 ***	
Term (ref)					-							-	
<37wks, FGR<.85, <2500g						81.62 ***							17.97 ***
<37wks, FGR≥.85, <2500g						72.83 ***							16.88 ***
≥37wks, FGR<.85, <2500g						10.06 ***							6.37 ***
<37wks, FGR≥.85, ≥2500g						3.11 ***							3.03 ***
≥37wks, FGR<.85, ≥2500g						2.22 ***							2.31 ***
≥37wks, FGR≥.85, ≥2500g (ref)						-							-
Std. gestation-age-specific birthweight							0.57 ***						
Apgar score								0.42 ***					
Low Apgar score									558.63 ***	73.52 ***	86.07 ***	151.12 ***	150.01 ***
Medium Apgar score									77.28 ***	14.56 ***	16.85 ***	24.16 ***	24.02 ***
High Apgar score									-	-	-	-	-
R^2	0.3771	0.2271	0.3879	0.3648	0.2530	0.2539	0.0493	0.4535	0.4429	0.5062	0.4996	0.4854	0.4863

*Note: * indicates significant at the 1% level; ** significant at the 5% level; *** significant at the 1% level (two-tailed test).*

Table 27: Results of multivariate analysis of late neonatal mortality, black male infants

	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8	model 9	model 10	model 11	model 12	model 13
	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR
Covariates													
Mother's age (reference group: between 20 and 34)													
<20	1.06	0.942	1.04	0.972	0.921	0.93	0.90	1.03	1.00	1.09	1.03	0.99	0.99
>34	1.05	1.083	1.05	1.057	1.063	1.07	1.34 *	1.12	1.17	1.00	1.01	1.00	1.01
Married	1.1	1.145	1.09	1.104	1.14	1.14	1.11	1.15	1.17	1.18	1.19	1.21	1.20
Mother born in US	1.03	1.057	1.07	1.087	1.093	1.09	1.13	1.00	1.05	0.94	0.96	0.96	0.95
Mother's education (reference group: high school graduates)													
< high school	1.1	1.104	1.11	1.098	1.0879	1.09	1.18	1.09	1.08	1.01	1.00	1.00	1.00
≥college	1.14	1.107	1.12	1.106	1.0928	1.10	1.04	1.14	1.10	1.21	1.19	1.19	1.21
Father unreported	1.4 ***	1.499 ***	1.37	1.345 **	1.4796	1.49 ***	1.59 ***	1.44 ***	1.46 **	1.29 *	1.26 *	1.34 **	1.35 **
Birth order risk (reference group: Low parity)													
First birth	0.99	1.13	1.02	1.115	1.1757	1.16	1.23	1.29 *	1.29 *	1.05	1.15	1.18	1.16
High parity	0.94	0.89	0.94	0.905	0.8898	0.89	0.96	0.97	0.96	0.92	0.89	0.89	0.90
APNCU (reference group: Adequate)													
inadequate care	1.21	1.593 **	1.13	0.997	1.2819	1.30	2.41 ***	2.08 ***	1.10	1.07	1.16	1.10	1.09
intermediate care	0.99	1.035	1.04	1.12	1.0632	1.05	1.10	1.06	2.22 ***	1.19	1.08	1.32	1.35
adequate plus care	1.21	1.959 ***	1.1	1.013	1.3732 *	1.39 *	3.86 ***	3.29 ***	3.38 ***	1.22	1.16	1.50 **	1.52 **
tobacco use	-	-	-	-	-	-	-	1.86 ***	1.84 ***	1.60 ***	1.67 ***	1.57 ***	1.55 ***
alcohol use	1.12	1.201	1.17	1.276	1.2151	1.20	1.63	1.36	1.34	0.95	1.02	1.03	1.01
California	0.9	0.916	0.83	0.843	0.8341	0.83	0.84	-	-	-	-	-	-
Key Independent Variables													
Birth weight (100g)	0.82 ***		0.85 ***							0.86 ***			
LBW		20.89 ***		4.549 ***							4.03 ***		
Gestational age (wk)			0.93 ***	0.79 ***						0.94 **	0.82 ***		
Preterm LBW					33.399 ***							19.43 ***	
Large-for-gestation					2.2142 ***							2.00 ***	
IUGR					5.7515 ***							4.88 ***	
Term (ref)					-							-	
<37wks, FGR<.85, <2500g						39.62 ***							23.44 ***
<37wks, FGR≥.85, <2500g						26.65 ***							15.26 ***
≥37wks, FGR<.85, <2500g						6.16 ***							5.29 ***
<37wks, FGR≥.85, ≥2500g						2.36 ***							2.15 ***
≥37wks, FGR<.85, ≥2500g						1.76 *							1.86 **
≥37wks, FGR≥.85, ≥2500g (ref)						-							-
Std. gestation-age-specific birthweight							0.56 ***						
Apgar score								0.56 ***					
Low Apgar score									38.19 ***	2.37 ***	3.12 ***	10.03 ***	9.89 ***
Medium Apgar score									20.89 ***	2.25 ***	2.93 ***	5.91 ***	5.91 ***
High Apgar score (ref)									-	-	-	-	-
R^2	0.2414	0.1528	0.2422	0.2208	0.1680	0.1698	0.0451	0.1290	0.1127	0.25	0.2308	0.1996	0.2017

*Note: * indicates significant at the 1% level; ** significant at the 5% level; *** significant at the 1% level (two-tailed test).*

Table 28: Results of multivariate analysis of postneonatal mortality, black male infants

	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8	model 9	model 10	model 11	model 12	model 13
	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR
Covariates													
Mother's age (reference group: between 20 and 34)													
<20	1.36 ***	1.33 ***	1.34 ***	1.31 ***	1.30 ***	1.30 ***	1.30 ***	1.39 ***	1.37 ***	1.38 ***	1.36 ***	1.35 ***	1.35 ***
>34	0.71 ***	0.73 ***	0.71 ***	0.71 ***	0.72 ***	0.72 ***	0.83	0.79 *	0.81 *	0.73 **	0.73 ***	0.73 **	0.74 **
Married	0.92	0.91	0.92	0.91	0.92	0.92	0.90	0.94	0.95	0.98	0.97	0.98	0.98
Mother born in US	1.48 ***	1.55 ***	1.52 ***	1.58 ***	1.58 ***	1.56 ***	1.58 ***	1.60 ***	1.63 ***	1.49 ***	1.54 ***	1.54 ***	1.53 ***
Mother's education (reference group: high school graduates)													
< high school	1.09	1.10	1.10	1.10	1.10	1.10	1.15	1.16	1.15	1.10	1.10	1.11	1.11
≥college	0.89	0.86 **	0.88 *	0.86 **	0.86 **	0.86 **	0.84 **	0.84 **	0.83 **	0.88	0.87 *	0.87 *	0.87 *
Father unreported	1.10	1.13 *	1.09	1.09	1.13 *	1.13 *	1.16 **	1.13	1.14 *	1.08	1.08	1.10	1.10
Birth order risk (reference group: Low parity)													
First birth	0.75 ***	0.80 ***	0.77 ***	0.82 **	0.82 **	0.82 ***	0.82 ***	0.81 **	0.82 **	0.75 ***	0.80 ***	0.79 ***	0.78 ***
High parity	1.28 ***	1.27 ***	1.26 ***	1.24 ***	1.26 ***	1.26 ***	1.32 ***	1.31 ***	1.30 ***	1.26 ***	1.24 ***	1.26 ***	1.26 ***
APNCU (reference group: Adequate)													
inadequate care	1.23 **	1.39 ***	1.17	1.11	1.29 ***	1.29 ***	1.71 ***	1.56 ***	1.24	1.25 *	1.31 **	1.24 *	1.23
intermediate care	1.25 *	1.27 *	1.30 **	1.37 ***	1.28 **	1.28 **	1.29 **	1.23	1.61 ***	1.19 *	1.15	1.28 **	1.28 **
adequate plus care	1.00	1.23 ***	0.90	0.86 *	1.08	1.09	1.78 ***	1.56 ***	1.59 ***	0.94	0.90	1.09	1.09
tobacco use	-	-	-	-	-	-	-	1.48 ***	1.48 ***	1.29 ***	1.35 ***	1.32 ***	1.30 ***
alcohol use	1.20	1.28	1.23	1.30	1.29	1.28	1.55 **	1.26	1.27	1.01	1.04	1.05	1.04
California	0.94	0.92	0.88	0.88	0.86	0.86	0.89	-	-	-	-	-	-
Key Independent Variables													
Birth weight (100g)	0.87 ***		0.90 ***							0.91 ***			
LBW		7.25 ***		3.12 ***							2.89 ***		
Gestational age (wk)			0.94 ***	0.85 ***						0.95 ***	0.88 ***		
Preterm LBW					9.60 ***							6.70 ***	
Large-for-gestation					1.32 **							1.23 *	
IUGR					4.05 ***							3.57 ***	
Term (ref)					-							-	
<37wks, FGR<.85, <2500g						10.68 ***							7.51 ***
<37wks, FGR≥.85, <2500g						8.83 ***							6.13 ***
≥37wks, FGR<.85, <2500g						4.27 ***							3.78 ***
<37wks, FGR≥.85, ≥2500g						1.39 ***							1.29 **
≥37wks, FGR<.85, ≥2500g						1.55 ***							1.57 ***
≥37wks, FGR≥.85, ≥2500g (ref)						-							-
Std. gestation-age-specific birthweight							0.65 ***						
Apgar score								0.61 ***					
Low Apgar score									17.82 ***	2.90 ***	3.79 ***	7.23 ***	7.16 ***
Medium Apgar score									11.35 ***	2.70 ***	3.31 ***	4.86 ***	4.85 ***
High Apgar score									-	-	-	-	-
R^2	0.1082	0.0742	0.1117	0.0995	0.0792	0.0802	0.0288	0.0662	0.0573	0.1194	0.1102	0.0983	0.0994

*Note: * indicates significant at the 1% level; ** significant at the 5% level; *** significant at the 1% level (two-tailed test).*

Table 29: Results of multivariate analysis of early neonatal mortality, Mexican male infants

	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8	model 9	model 10	model 11	model 12	model 13
	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR
Covariates													
Mother's age (reference group: between 20 and 34)													
<20	1.14	1.11	1.10	1.00	1.04	1.03	1.10	1.28	1.21	1.21	1.18	1.16	1.16
>34	1.11	1.23	1.07	1.05	1.15	1.15	1.67 ***	0.97	0.87	0.87	0.83	0.87	0.87
Married	1.24 **	1.24 **	1.25 **	1.23 *	1.24 **	1.25 **	1.20 *	1.42	1.33	1.45 *	1.49 *	1.51 *	1.51 *
Mother born in US	0.83 *	0.86	0.80 *	0.83 *	0.84	0.84	0.94	1.26	1.12	1.04	1.06	1.09	1.08
Mother's education (reference group: high school graduates)													
< high school	1.05	1.04	1.02	0.99	1.01	1.01	1.06	0.86	0.87	0.87	0.85	0.85	0.84
≥college	0.83	0.78 *	0.82	0.80	0.76 *	0.76 *	0.76 *	0.46 **	0.55 *	0.65	0.65	0.62	0.62
Father unreported	1.27 *	1.31 *	1.23	1.22	1.29 *	1.28 *	1.32 **	1.13	1.26	1.45	1.43	1.41	1.40
Birth order risk (reference group: Low parity)													
First birth	0.87	0.95	0.86	0.95	0.97	0.95	1.09	0.98	0.88	0.74	0.78	0.82	0.82
High parity	1.20	1.18	1.18	1.10	1.14	1.14	1.24 *	1.35	1.15	0.96	0.91	0.90	0.90
APNCU (reference group: Adequate)													
inadequate care	1.53 ***	1.67 ***	1.40	1.17	1.41 **	1.39 *	2.50 ***	2.29 ***	0.79	0.88	0.92	0.85	0.84
intermediate care	1.35	1.34	1.39	1.49 *	1.43	1.42	1.40	0.82	2.18 ***	1.67 *	1.60	1.64 *	1.62
adequate plus care	1.32 *	1.80 ***	1.05	0.92	1.23	1.23	3.91 ***	2.46 ***	2.42 ***	1.33	1.19	1.27	1.27
tobacco use	0.60	0.87	0.54	0.62	0.89	0.89	1.11	0.37	0.38	0.25 **	0.26 *	0.28 *	0.27 *
alcohol use	-	-	-	-	-	-	-	0.76	1.00	1.33	1.22	0.85	0.86
California	1.22 **	1.22 **	1.23 **	1.24 **	1.24 **	1.24 **	1.10	-	-	-	-	-	-
Key Independent Variables													
Birth weight (100g)	0.79 ***		0.81 ***							0.86 ***			
LBW		61.20 ***		13.20 ***							9.11 ***		
Gestational age (wk)			0.94 ***	0.77 ***						1.02	0.91 ***		
Preterm LBW					107.03 ***							21.17 ***	
Large-for-gestation					3.10 ***							2.73 ***	
IUGR					24.04 ***							16.00 ***	
Term (ref)					-							-	
<37wks, FGR<.85, <2500g						131.19 ***							22.32 ***
<37wks, FGR≥.85, <2500g						150.30 ***							26.60 ***
≥37wks, FGR<.85, <2500g						30.19 ***							17.41 ***
<37wks, FGR≥.85, ≥2500g						3.87 ***							2.84 ***
≥37wks, FGR<.85, ≥2500g						3.75 ***							2.00
≥37wks, FGR≥.85, ≥2500g (ref)						-							-
Std. gestation-age-specific birthweight							0.42 ***						
Apgar score								0.37 ***					
Low Apgar score									1232.56 ***	224.52 ***	248.24 ***	323.63 ***	322.41 ***
Medium Apgar score									103.65 ***	21.50 ***	22.85 ***	29.14 ***	28.80 ***
High Apgar score									-	-	-	-	-
R^2	0.3365	0.2529	0.359	0.334	0.2684	0.2719	0.0824	0.4933	0.4652	0.5409	0.5401	0.5358	0.5363

*Note: * indicates significant at the 1% level; ** significant at the 5% level; *** significant at the 1% level (two-tailed test).*

Table 30: Results of multivariate analysis of late neonatal mortality, Mexican male infants

	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8	model 9	model 10	model 11	model 12	model 13
	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR
Covariates													
Mother's age (reference group: between 20 and 34)													
<20	1.03	1.01	1.04	0.99	1.02	1.01	0.99	0.88	0.86	0.85	0.83	0.83	0.84
>34	0.96	1.05	0.99	0.96	1.07	1.06	1.33	1.25	1.21	0.96	0.94	1.07	1.08
Married	0.92	0.90	0.96	0.94	0.95	0.95	0.89	0.76	0.76	0.80	0.79	0.80	0.80
Mother born in US	1.25	1.31 *	1.23	1.27	1.29	1.28	1.39 **	1.30	1.22	1.17	1.19	1.19	1.18
Mother's education (reference group: high school graduates)													0.99
< high school	1.09	1.09	1.05	1.03	1.04	1.04	1.10	1.67 **	1.64 **	1.57 *	1.55 *	1.56 *	
≥college	0.93	0.89	0.94	0.91	0.88	0.89	0.88	0.87	0.90	0.96	0.94	0.94	1.57 *
Father unreported	1.00	1.01	1.06	1.04	1.10	1.09	1.03	0.96	1.00	0.98	0.98	0.99	0.95
Birth order risk (reference group: Low parity)													
First birth	0.93	1.02	0.96	1.07	1.07	1.05	1.10	1.62	1.59	1.32	1.44	1.46	1.43
High parity	1.43 *	1.40 *	1.43 *	1.38 *	1.41 *	1.41 *	1.45 **	2.59 ***	2.44 ***	2.31 ***	2.23 ***	2.27 ***	2.29 ***
APNCU (reference group: Adequate)													
inadequate care	0.88	1.04	0.81	0.73	0.90	0.89	1.34	1.16	1.08	1.05	1.14	1.06	1.04
intermediate care	1.00	1.04	1.05	1.14	1.09	1.08	1.06	1.08	1.20	0.81	0.78	0.87	0.88
adequate plus care	0.82	1.16	0.72 *	0.66 **	0.88	0.89	2.01 ***	1.47	1.53	0.71	0.69	0.87	0.90
tobacco use	0.73	0.97	0.70	0.77	1.00	0.99	1.18	2.18	2.17	1.58	1.63	1.62	1.65
alcohol use	-	-	-	-	-	-	-	1.27	1.40	2.15	2.04	1.40	1.33
California	0.95	0.93	0.97	0.96	0.96	0.96	0.88	-	-	-	-	-	-
Key Independent Variables													
Birth weight (100g)	0.81 ***		0.85 ***							0.87 ***			
LBW		24.67 ***		6.23 ***							4.60 ***		
Gestational age (wk)			0.91 ***	0.79 ***						0.92 *	0.82 ***		
Preterm LBW					39.41 ***							17.68 ***	
Large-for-gestation					2.29 ***							2.38 **	
IUGR					10.24 ***							8.31 ***	
Term (ref)					-							-	
<37wks, FGR<.85, <2500g						43.56 ***							19.37 ***
<37wks, FGR≥.85, <2500g						49.39 ***							14.02 ***
≥37wks, FGR<.85, <2500g						11.59 ***							8.79 ***
<37wks, FGR≥.85, ≥2500g						2.50 ***							2.22 *
≥37wks, FGR<.85, ≥2500g						2.44 ***							1.84
≥37wks, FGR≥.85, ≥2500g (ref)						-							-
Std. gestation-age-specific birthweight							0.49 ***						
Apgar score								0.51 ***					
Low Apgar score									64.81 ***	4.40 **	6.69 ***	16.98 ***	17.29 ***
Medium Apgar score									33.18 ***	3.91 ***	5.04 ***	9.69 ***	9.88 ***
High Apgar score									-	-	-	-	-
R^2	0.2012	0.1301	0.2028	0.1821	0.1400	0.1422	0.0427	0.1159	0.1008	0.2039	0.1909	0.1692	0.1697

*Note: * indicates significant at the 1% level; ** significant at the 5% level; *** significant at the 1% level (two-tailed test).*

Table 31: Results of multivariate analysis of postneonatal mortality, Mexican male infants

	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8	model 9	model 10	model 11	model 12	model 13
	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR
Covariates													
Mother's age (reference group: between 20 and 34)													
<20	1.73 ***	1.77 ***	1.76 ***	1.77 ***	1.80 ***	1.78 ***	1.73 ***	2.26 ***	2.23 ***	2.16 ***	2.17 ***	2.19 ***	2.18 ***
>34	0.90	0.91	0.85	0.83	0.87	0.86	1.03	0.93	0.93	0.83	0.82	0.85	0.85
Married	0.75 ***	0.74 ***	0.74 ***	0.73 ***	0.73 ***	0.74 ***	0.74 ***	0.66 ***	0.66 ***	0.68 **	0.68 **	0.68 **	0.68 **
Mother born in US	1.30 ***	1.34 ***	1.31 ***	1.34 ***	1.35 ***	1.34 ***	1.37 ***	1.38 **	1.36 **	1.28	1.30 *	1.30 *	1.30 *
Mother's education (reference group: high school graduates)													
< high school	1.05	1.06	1.03	1.03	1.03	1.03	1.07	0.79	0.79	0.78	0.78	0.78	0.78
≥college	0.88	0.85	0.89	0.88	0.88	0.88	0.85	1.15	1.16	1.20	1.18	1.19	1.20
Father unreported	1.13	1.13	1.08	1.09	1.11	1.10	1.13	0.88	0.90	0.85	0.85	0.86	0.86
Birth order risk (reference group: Low parity)													
First birth	0.64 ***	0.67 ***	0.64 ***	0.68 ***	0.67 ***	0.66 ***	0.67 ***	0.77	0.78	0.70 *	0.74	0.73 *	0.71 *
High parity	1.09	1.07	1.10	1.08	1.09	1.09	1.09	1.42 *	1.39 *	1.38 *	1.35	1.35	1.35
APNCU (reference group: Adequate)													
inadequate care	1.65 ***	1.77 ***	1.57 ***	1.57 ***	1.68 ***	1.65 ***	1.94 ***	1.62 **	1.21	1.20	1.26	1.19	1.18
intermediate care	1.20	1.22	1.24	1.31	1.22	1.21	1.21	1.20	1.66 **	1.32	1.32	1.39	1.37
adequate plus care	1.46 ***	1.60 ***	1.30 **	1.25 *	1.47 ***	1.47 ***	2.03 ***	1.64 ***	1.67 ***	1.07	1.05	1.18	1.19
tobacco use	2.08	2.26 *	2.05	2.12	2.26 *	2.23 *	2.56 **	1.58	1.61	1.40	1.44	1.41	1.38
alcohol use	-	-	-	-	-	-	-	2.78 *	2.81 *	3.11 **	2.97 *	2.71 *	2.70 *
California	0.87	0.85	0.89	0.88	0.87	0.87	0.85 *	-	-	-	-	-	-
Key Independent Variables													
Birth weight (100g)	0.88 ***		0.90 ***							0.90 ***			
LBW		7.50 ***		3.90 ***							4.36 ***		
Gestational age (wk)			0.94 ***	0.87 ***						0.94 *	0.89 ***		
Preterm LBW					9.09 ***							8.52 ***	
Large-for-gestation					1.55 ***							1.65 **	
IUGR					5.95 ***							6.47 ***	
Term (ref)					-							-	
<37wks, FGR<.85, <2500g						9.03 ***							8.88 ***
<37wks, FGR≥.85, <2500g						15.12 ***							11.76 ***
≥37wks, FGR<.85, <2500g						6.57 ***							7.08 ***
<37wks, FGR≥.85, ≥2500g						1.73 ***							1.78 **
≥37wks, FGR<.85, ≥2500g						1.97 ***							1.89 ***
≥37wks, FGR≥.85, ≥2500g (ref)						-							-
Std. gestation-age-specific birthweight							0.62 ***						
Apgar score								0.60 ***					
Low Apgar score									15.40 ***	2.65	3.81 **	6.35 ***	6.14 ***
Medium Apgar score									12.62 ***	3.10 ***	3.75 ***	5.40 ***	5.34 ***
High Apgar score									-	-	-	-	-
R^2	0.0701	0.0582	0.0774	0.0696	0.0604	0.0635	0.0342	0.0549	0.0475	0.0958	0.0925	0.0867	0.0889

*Note: * indicates significant at the 1% level; ** significant at the 5% level; *** significant at the 1% level (two-tailed test).*

Bibliography

Abma J, Chandra A, Mosher W, Peterson L, Piccinino L. "Fertility, family planning, and women's health: new data from the 1995 National Survey of Family Growth." *Vital Health Stat.* 1997; 23(19): 49-58.

Abrevaya J. "The effects of demographics and maternal behavior on the distribution of birth outcomes." *Empirical Economics* 2001; 26: 247-257.

Almond D, Chay KY, Lee DS. "The Costs of Low Birth Weight." *The Quarterly Journal of Economics*. 2005; 120 (3): 1031-1083

Allison P. (2001). *Missing Data*. Thousand Oaks CA: Sage.

Barker DJ. "Fetal Origins of Coronary Heart Disease." *British Medical Journal. 1995;* 311: 171-74

Barker DJP, Eriksson JG, Forsén *T,* Osmond C. "Fetal origins of adult disease: strength of effects and biological basis." *International Journal of Epidemiology*. 2002: 31:1235-1239

Berg CJ, Wilcox LS, d'Almada PJ. "The Prevalence of Socioeconomic and Behavioral Characteristics and Their Impact on Very Low Birth Weight in Black and White Infants in Georgia." *Matern Child Health J.* 2001; 5(2): 75-84.

Birth Data, National Vital Statistics System. Available at: http://www.cdc.gov/nchs/births.htm Accessed October 1, 2006

Boardman, J.D., D.A. Powers, Y.C. Padilla, R.A. Hummer. 2002. "Low Birth Weight, Societal Factors, and Developmental Outcomes." *Demography* 39:353-68.

Brown S, Eisenberg L, eds. The Best Intentions: Unintended Pregnancy and the Well-Being of Children and Families. Washington, DC: National Academy Press; 1995.

Casey BM, McIntire DD, Leveno KJ. "The continuing value of the Apgar score for the assessment of newborn infants." *N Engl J Med*. 2001; 344(7):467-71.

Centers for Disease Control and Prevention. State-Specific Prevalence of Current Cigarette Smoking Among Adults: 2003. *JAMA*. 2004; 292(24). Table is available at: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5344a2.htm Accessed October 1, 2006.

Collins JJ, David RJ. Race and birthweight in biracial infants. *Am J Public Health*. 1993; 83(8): 1125-9.

Conley, D., K.W. Strully, N.G. Bennett. 2003. *The Starting Gate: Birth-weight and Life Chances*. Berkeley: University of California Press

Cunningham FG, et al., Fetal growth restriction. Williams Obstetrics. 20th ed. Stamford, Conn.: Appleton & Lange, 1997:839-54.

DaVita CJ. 1996. "The United States at Mid-Decade." Population Bulletin 50(4). Washington, D.C.: Population Reference Bureau.

Department of Health and Human Services. *Healthy People 2010: Understanding and Improving Health*. 2nd ed. Washington, DC: U.S. Government Printing Office, November 2000. Available at: http://www.healthypeople.gov/Document/html/uih/uih_bw/uih_2.htm#goals. Accessed October 1, 2006

Doyle MJ, Echevarria S, Parker FW. 2003. "Race/Ethnicity, Apgar and Infant Mortality." *Population Research and Policy Review*, 22(1): 41-64

ECLS-B, Early Childhood Longitudinal Study, Birth Cohort (ECLS-B) User's Manual for the ECLS-B Nine-Month Restricted-Use Data File and Electronic Code Book

Eriksson JG, Forsen T, Tuomilehto J, Osmond C, Barker DJP. (2001) "Early growth and coronary heart disease in later life: longitudinal study." *BMJ.* 322(7292): 949–953.

Frank R. 2001. "A Reconceptualization of the Role of Biology in Contributing to Race/Ethnic Disparities in Health Outcomes." *Population Research and Policy Revie*w 20(6): 441-455.

Frisbie WP, Forbes D, Pullum SG. 1996. "Compromised Birth Outcomes and Infant Mortality Among Racial and Ethnic Groups." *Demography* 33 (4): 469-481.

Frisbie WP, Song SE, Powers DA, Street JA. "The increasing racial disparity in infant mortality: respiratory distress syndrome and other causes." *Demography*. 2004; 41(4):773-800.

Foster HW, Wu L, Bracken MB, Semenya K, Thomas J,Thomas J. Intergenerational Effects of High Socioeconomic Status on Low Birthweight and Preterm Birth in African Americans. *J Natl Med Assoc.* 2000; 92(5): 213-221.

Fu VK. Racial Intermarriage Pairings. *Demography*. 2001; 38(2): 147-159

Fuchs VR. *Who Shall Live: health, economics, and social choice.* 2nd ed. Singapore: World Scientific Publishing Company Pte. Ltd.; 1998

Geronimus AT. 1996 "Black/white Differences in the Relationship of Maternal Age to Birthweight: a Population-based Test of the Weathering Hypothesis." *Soc. Sci. Med* 42: 589-597

Getahun D, Ananth CV, Selvam N, Demissie K. Adverse Perinatal Outcomes Among Interracial Couples in the United States. *Obstet Gynecol*. 2005; 106(1): 81-8.

Gjessing HK, Skjaerven R, Wilcox AJ. "Errors in gestational age: evidence of bleeding early in pregnancy." *Am J Public Health.* 1999; 89(2): 213–218.

Gould JB, Chavez G, Marks AR, Liu H. Incomplete Birth Certificates: A Risk Marker for Infant Mortality. *Am J Public Health.* 2002; 92(1): 79–81.

Hack M, Flannery DJ, Schluchter M, Cartar L, Borawski E, Klein N. 2002. "Outcomes in Young Adulthood for Very-Low-Birth-Weight Infants." *New England Journal of Medicine* 346: 149-157.

Hamilton BE, Ventura SJ, Martin JA, Sutton PD. Preliminary births for 2004. Health E-stats. Hyattsville, MD: National Center for Health Statistics. Released October 28, 2005.

Hegyi T, Carbone T, Anwar M, Ostfeld B, Hiatt M, Koons A, Pinto-Martin J, Paneth N. "The apgar score and its components in the preterm infant." *Pediatrics.* 1998; 101: 77-81.

Hessol NA, Fuentes-Afflick E, Bacchetti P. "Risk of low birth weight infants among black and white parents." *Obstet Gynecol.* 1998; 92(5): 814-22.

Hessol NA, Fuentes-Afflick E. "Ethnic Differences in Neonatal and Postneonatal Mortality." *Pediatrics*. 2005; 115 (1): e44-e51

Hoekelman RA, Pless IB. "Decline in mortality among young Americans during the 20th century: prospects for reaching national mortality reduction goals for 1990." *Pediatrics.* 1988; 82: 582–595.

Hogue CJ, Vasquez C. "Toward a strategic approach for reducing disparities in infant mortality." *Am J Public Health*. 2002 Apr;92(4):552-6.

Hoekelman RA, Pless IB. "Decline in mortality among young Americans during the 20th century: prospects for reaching national mortality reduction goals for 1990." *Pediatrics.* 1988; 82: 582–595.

Hummer RA. "Racial Differentials in Infant Mortality in the U.S.: an Examination of Social and Health Determinants." *Social Forces*. 1993; 72(2): 529-554

Hummer RA, Biegler M, De Turk PB, Forbes D, Frisbie WP, Hong Y, Pullum SG. "Race/Ethnicity, Nativity, and Infant Mortality in the United States." *Social Forces.* 1999; 77(3): 1083-1117

Finch BK. "Socioeconomic gradients and low birth-weight: empirical and policy considerations." *Health Serv Res.* 2003; 38(6 Pt 2):1819-41.

Forsén T, Eriksson J, Tuomilehto J, Reunanen A, Osmond C, Barker D. (2000) "The Fetal and Childhood Growth of Persons Who Develop Type 2 Diabetes." *Annals of Internal Medicine*. 133: 176-182).

Kempe A, Wise PH, Wampler NS, Cole FS, Wallace H, Dickinson C, Rinehart H, Lezotte DC, Beaty B. "Risk status at discharge and cause of death for postneonatal infant deaths: a total population study." *Pediatrics*. 1997; 99(3):338-44.

Kramer MS. "Determinants of low birth weight: methodological assessment and meta-analysis." Bull World Health Org 1987; 65:663-737

Kogan MD. "Social causes of low birth weight." J R Soc Med 1995; 88: 611-615
Imbens, G. 2003. "Nonparametric Estimation of Average Treatment Effects Under Exogeneity: a Review," Technical Working Paper 294, National Bureau of Economic Research.

Kotelchuck M. "An evaluation of the Kessner Adequacy of Prenatal Care Index and a proposed Adequacy of Prenatal Care Utilization Index." *Am J Public Health.* 1994; 84(9):1414-20.

Kotelchuck M. " The Adequacy of Prenatal Care Utilization Index: its US distribution and association with low birthweight." *Am J Public Health.* 1994; 84(9):1486-9.

Infant mortality and low birth weight among black and white infants—United States, 1980–2002. *MMWR Morb Mortal Wkly Rep.* 2002; 51(27): 589–592 http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5127a1.htm

Joseph KS, Wilkins R, Dodds L, Allen VM, Ohlsson A, Marcoux S, Liston R. "Customized birth weight for gestational age standards: Perinatal mortality patterns are consistent with separate standards for males and females but not for blacks and whites." *BMC Pregnancy and Childbirth.* 2005; 5(3)

Lewit EM, Baker LS, Corman H, Shiono PH. 1995. "The Direct Costs of Low Birth Weight." *The Future of Children* 5: 35-51.

Luke B, Williams C, Minogue J, Keith L. "The Changing Pattern of Infant Mortality in the United States". *InternalJournal of Gynecological Obstetrics. 1993;* 40(3): 199-212.

Luke B, Brown MB. "The changing risk of infant mortality by gestation, plurality, and race: 1989-1991 versus 1999-2001." *Pediatrics*. 2006;118(6):2488-97

Martin JA, Hamilton BE, Sutton PD, Ventura SJ, Menacker F, Munson ML. Births: Final data for 2002. *National vital statistics reports*. 2003; 52 (10). Hyattsville, Maryland: National Center for Health Statistics. Available at: http://www.cdc.gov/nchs/data/nvsr/nvsr52/nvsr52_10.pdf. Accessed October 1, 2006

Mathews TJ, Menacker F, MacDorman MF. Infant mortality statistics from the 2001 period linked birth/infant death data set. *Natl Vital Stat Rep.* 2003; 52(2):1–28

McCaffrey D, Ridgeway G, Morral A. Propensity score estimation with boosted regression for evaluating adolescent substance abuse treatment. *Psychological Methods.* 2004; 9(4):403-425

McCormick MC. "Deconstructing low birth weight." Conference paper 2006

Migone A, Emanuel I, Mueller B, Daling J, Little RE. Gestational duration and birthweight in white, black and mixed-race babies. *Paediatr Perinat Epidemiol.* 1991; 5(4): 378-91.

Miniño AM, Heron M, Smith BL. Deaths: Preliminary data for 2004. *Health E-Stats.* Released April 19, 2006.

Morenoff J. 2003."Neighborhood Mechanisms and the Spatial Dynamics of Birth Weight." *AJS* 108(5): 976-1017.

National Institutes of Health: Black, White Teens Show Differences in Nicotine Metabolism. Available at: http://www.nih.gov/news/pr/jan2006/nida-20.htm. Accessed October 2006.

National Center for Health Statistics. Linked Birth/Infant Death Data Set - 2001 Denominator Record and Natality Section of Numerator (Linked) Record. Available at: http://wonder.cdc.gov/wonder/sci_data/natal/linked/type_txt/lbd01/Recordlayout01.pdf. Accessed October 2, 2006

National Center for Health Statistics Health, United States, 2006 With Chartbook on Trends in the Health of Americans Hyattsville, MD: 2006

OMB report: http://www.whitehouse.gov/omb/inforeg/race.pdf

Paneth N. "The Problem of Low Birth Weight". *Future Child*. 1995; 5(1): 19-34.

Papile L. "The Apgar score in the 21st century [Editorial]." *NEJM* 344:519-520

Parker J. Birth weight trends among interracial black and white infants. *Epidemiology.* 2000; 11(3): 237-9.

Parker JD, Schoendorf KC, Kiely JL. "Associations between measures of socioeconomic status and low birth weight, small for gestational age, and premature delivery in the United States." *Annals of Epidemiology* 1994; 4: 271-278.

Petrikovsky BM, Diana L., Baker DA. "Race and Apgar scores [Correspondence]." *Anesthesia* 45:988-999

Perreira KM, Cortes KE. Race/ethnicity and nativity differences in alcohol and tobacco use during pregnancy. *Am J Public Health*. 2006; 96(9):1629-36

Pickett KE, Pearl M. Multilevel analyses of neighbourhood socioeconomic context and health outcomes: a critical review. *J Epidemiol Community Health.* 2001; 55 (2): 111-122.

Polednak A, King G. "Birth weight of US biracial (black-white) infants: regional differences." *Ethn Dis.* 1998; 8(3): 340-9.

Reichman NE, Teitler JO. "Paternal age as a risk factor for low birthweight." *Am J Public Health.* 2006; 96(5): 862-866

Ridgeway G. 2005. *Generalized Boosted Models: A guide to the gbm package.* Available at: http://i-pensieri.com/gregr/papers/gbm-vignette.pdf. Accessed October 1, 2006

Ridgeway G. "Assessing the effect of race bias in post-traffic stop outcomes using propensity scores." *Journal of Quantitative Criminology* 2006; 22(1): 1-29.

Roger RG. "Ethnic and birth weight differences in cause-specific infant mortality." *Demography*. 1989; 26(2):335-43.

Roger K, Hallock KF. "Quantile regression." *Journal of Economic Perspectives. 2001;* 15:143-156.

Rosenbaum, P.R. and D.B. Rubin. "The Central Role of the Propensity Score in Observational Studies for Causal Effects." *Biometrika. 1983;* 70(1): 41-55.

Rosenbaum P. "Model-based Direct Adjustment," *Journal of the American Statistical Association* 1987; 82: 7–394.

Samuelsen SO, Bakketeig LS, Tretli S, Johannesen TB, Magnus P. "Head Circumference at Birth and Risk of Brain Cancer in Childhood; a Population-Based Study." *Lancet Oncology.* 2006; 7: 39-42.

Sastry N, Hussey J. *Explaining Race and Ethnic Disparities in Birth Weight in Chicago Neighborhoods.* Santa Monica, CA, RAND Corporation: 1-49. 2002

Sastry N, Hussey J. "An Investigation of Racial and Ethnic Disparities in Birth Weight in Chicago Neighborhoods." *Demography.* 2003; 40 (4): 701-725.

Shiono PH, Rauh VA, Park M, Lederman SA, Zuskar D. "Ethnic differences in birthweight: the role of lifestyle and other factors." *Am J Public Health.* 1997; 87(5):787-93.

Solis P, Pullum SG, Frisbie WP. "Demographic Models of Birth Outcomes and Infant Mortality: An Alternative Measurement Approach." *Demography.* 2000; 37(4): 489-4978

Weinberger B, Anwar M, Hegyi T, Hiatt M, Koons A, Paneth N. "Antecedents and neonatal consequences of low Apgar scores in preterm newborns: a population study." *Arch Pediatr Adolesc Med.* 2000; 154(3):294-300.

Wilcox AJ, Russell IT. "Birthweight and Perinatal Mortality: III. Towards a New Method of Analysis." *International Journal of Epidemiology*. 1986; 15(2): 188-196

Wilcox AJ, Skjaerven R. "Birth weight and perinatal mortality: the effect of gestational age." *Am J Public Health. 1992;* 82(3): 378-382

Wilcox AJ. "Birth weight and perinatal mortality: the effect of maternal smoking." *Am J Epidemiol.* 1993; 137(10):1098-104

Wilcox AJ, Skjaerven R, Buekens P, Kiely J. "Birth weight and perinatal mortality. A comparison of the United States and Norway." *JAMA*. 1995; 273(9)

Wilcox AJ. "On the Importance—and the Unimportance—of Birthweight." *International Journal of Epidemiology*. 2001; 30: 1233-1241.

Wooldridge J. *Econometric Analysis of Cross Section and Panel Data*. Cambridge: MIT Press. 2002

Yama AZ, Marx GF. "Race and Apgar scores." *Anesthesia.*1991; 46: 330-331

Yang Q, Greenland S, Flanders WD. "Associations of Maternal Age- and Parity-related Factors with Trends in Low-birthweight Rates: United States, 1980 through 2000." *Am J of Public Health.* 2006; 96(5): 856-861.