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Disparities in Birth Weight
in Chicago Neighborhoods*

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Explaining Race and Ethnic Disparities in Birthweight in Chicago Neighborhoods[†]

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Abstract

This paper examines the contribution of neighborhood and maternal characteristics to birthweight differentials among infants born to non-Hispanic black, non-Hispanic white, and Mexican-origin Hispanic mothers (of any race). Linear regression models with neighborhood fixed effects were estimated using birth certificate records for all births in Chicago from 1990. About 30 percent of the black/white disparity and about 14 percent of the black/Mexican-origin Hispanic disparity were due to neighborhood conditions. Adjusting for neighborhood and maternal characteristics accounted for 64 percent of the black/white differential and 57 percent of the black/Mexican-origin Hispanic differential. Around half of the black/white differential and the black/Mexican-origin Hispanic differential in birthweight were due to differences, across racial/ethnic groups, in the relationship between measured characteristics and birthweight. Efforts to close the birthweight gap between non-Hispanic black and other infants must go beyond programs aimed solely at reducing the level of risk factors among African-American women. Future interventions also need to address the causes of differences in the effects of key risk factors across racial and ethnic groups.

1. Introduction

Group differences in health reflect unequal life chances. Studying these differences can reveal important etiological mechanisms in the pathway to disease and is also valuable for identifying the groups most in need of—and most likely to benefit from—societal investments in health (Preston and Taubman, 1994). For these reasons, explaining the large and persistent race and ethnic disparities in birth outcomes and infant health in the U.S. is a priority. Despite dramatic improvements over the past century in the health of all infants, significant differences persist. Today, black infants are about 2.5 times more likely to die than white infants (Hoyert et al. 2001), compared to 1.5 times in 1900 (Preston and Haines, 1991). The public health impact of this disparity is enormous but under appreciated. If black newborns faced the same mortality risk as white newborns, over 60 percent of black infant deaths—a total of about 5,000—would be averted each year.¹

Birthweight is a key indicator of the health of infants at birth, as well as of the mother's reproductive health. It is likely to play a key role in the production of race and ethnic group differences in infant survival because it is one of the strongest predictors of infant mortality risk (Cramer, 1987; Institute of Medicine, 1985; Mathews, MacDorman, and Menacker, 2002).² In

¹ In 1999 there were 605,970 black births (Ventura et al. 2001) and 8,822 black infant deaths (Hoyert et al. 2001). The white infant mortality rate in 1999 was .0057675 (Hoyert et al. 2001). Applying the white IMR to black births results in $605,970 \times .0057675 = 3,495$ expected infant deaths. Thus there were $8,822 \text{ actual} - 3,495 \text{ expected} = 5,327$ excess black infant deaths in 1999.

² In studying the effects of birthweight on infant mortality it is difficult to independently consider the effects of birthweight from those of prematurity because of the strong association between low birthweight and pre-term delivery (i.e., delivery before 37 weeks of gestation). In our analysis, we examine birthweight conditional on gestation length.

the mid-1990s, the mean birthweight for singleton black infants in the U.S. was 3,132 grams, about 277 grams less than the mean birthweight of 3,409 grams for whites (Martin, MacDorman, and Mathews, 1997). Compared to whites, the variation in black birthweights is also larger and skewed to the left. The net result is that black infants are more than twice as likely as white infants to be born at birthweights below 2,500 grams (Martin et al., 2002), where the risk of infant death is 24 times greater than for birthweights above 2,500 grams, and three times more likely than whites to be born at birthweights below 1,500 grams, where the risk of infant death is 100 times greater (Mathews, MacDorman, and Menacker, 2002).

The impact of birthweight appears to extend well beyond infancy. According to the fetal origins hypothesis (Barker, 1998), fetal undernutrition, for which low birthweight is a marker, may permanently program the body—for example, by reducing the numbers of cells in specific organs, changing the distribution of cell types, or influencing metabolic processes. These programmed changes are associated with a variety of chronic disease outcomes during adulthood and old age, such as diabetes (Barker et al., 1993), hypertension (Law et al., 1993), and cardiovascular disease (Rich-Edwards et al., 1997). In addition, birthweight may affect physiological and developmental outcomes extending from infancy through childhood and into adulthood. Studies have found a significant association between birthweight and school age disabilities (Avchen, Scott, and Mason 2001), behavioral problems (Sommerfelt, Ellertsen, and Markestad, 1993), school-age reading and math scores (Boardman et al., 2002; Jefferis, Power, and Hertzman, 2002), cognitive function during young adulthood (Sorensen et al., 1997; Richards et al., 2001), and adult educational attainment (Conley and Bennett, 2000), as well as reproductive outcomes such as low birthweight (Sanderson, Emanuel, and Holt, 1995; Wang et al., 1995), preterm birth (Porter et al., 1997), and gestational diabetes (Innes et al., 2002). It is

unclear, however, the extent to which birthweight has a causal effect on these outcomes (reflecting intrauterine malnutrition, for example) or, instead, reflects the influence of unmeasured family background or genetic factors or confounding through, for instance, postnatal nutrition and stimulation.

Nevertheless, the implication of this research is that improvements in birthweight are likely to have a large pay-off in several different domains. Most obviously, it will represent an important enhancement in infant and maternal health. Second, it will lead to better health and developmental outcomes during childhood and adolescence and lower levels of chronic disease during adulthood and old age. Finally, reducing birthweight disparities by race and ethnicity will contribute to a reduction of inequalities across these groups in an array of health outcomes.

The goal of this paper is to explain race and ethnic disparities in birthweight in the city of Chicago, Illinois. Our analysis drew on vital statistics data for all singleton births in 1990 registered to Chicago resident mothers. Vital statistics contain considerable information on mothers' characteristics and pregnancy-related circumstances. We estimated a comprehensive series of models to examine the role that these factors played in accounting for differences in birthweight. We also examined variation, by race and ethnicity, in the association between these characteristics and birthweight. Our analysis incorporated several methodological advances that distinguish it from previous work on this topic. Of particular note is that we estimated models with tract-level fixed effects that absorbed the influence of all neighborhood-level characteristics. We were able to include such a control because the data were geocoded to identify neighborhood of residence for each woman. This is a major advantage of using data from a single city, with the cost being a potential lack of generalizability of the findings to other areas.

Non-Hispanic blacks in Chicago in 1990 had significantly lower average birthweights

than non-Hispanic whites and Mexican-origin Hispanics. Birth outcomes were qualitatively very similar for non-Hispanic whites and Mexican-origin Hispanics, which is remarkable because the latter group was comprised largely of first-generation immigrants with relatively low levels of education and other disadvantages. This “Hispanic paradox” has been widely noted in the literature (e.g., Gorman, 1999; Fuentes-Afflick and Lurie, 1997; Buekens et al., 2000). The results from our regression analysis indicate that neighborhood-level factors, socioeconomic and demographic background variables, and pregnancy-related behaviors accounted for a substantial portion of differences in birthweight across the three race and ethnic groups. In particular, these variables explained between half and two-thirds of the difference in average birthweight between non-Hispanic blacks and whites (and similar proportions when blacks were compared with Mexican-origin Hispanics); on the other hand, the variables accounted for *all* of the difference between non-Hispanic whites and Mexican-origin Hispanics.³ There was, in addition, important variation in the effects of certain variables across the three race and ethnic groups. These differences, together with the effects of unmeasured or unmeasurable variables, accounted for the

³ Previous studies have explained substantially less of the disparities between non-Hispanic blacks and other race and ethnic groups in birthweight or the risk of low birthweight (Institute of Medicine, 1985). For example, Shiono et al. (1997) investigated 46 previously defined and new potential risk factors and found that, at best, they could account for less than one-third of the gap in birthweight between African-Americans and whites in Chicago and New York. Berg, Wilcox, and d’Almada (2001) found that socioeconomic and behavioral factors explained approximately 10-15 percent of the higher rate of very low birthweight among black mothers in Georgia. Finally, Gorman (1999), using the linked birth and death data set for 1990, reported that the unadjusted risk of a low birthweight birth was 2.637 times greater for non-Latino blacks than for non-Latino whites; after adjusting for a set of individual-level and county-level covariates, the odds ratio dropped to only 2.165. In contrast, a number of previous studies have fully accounted for birthweight disparities between Hispanics and non-Hispanic whites with a standard set of covariates (e.g., Hessol and Fuentes-Afflick, 2000).

remainder of the gaps in birthweight by race and ethnicity.

The paper is organized as follows. We begin, in the next section, with a description of our conceptual framework and modeling approach. In Section 3, we outline our statistical methods. In Section 4, we provide a detailed overview of the data and the covariates that we considered. We present the model results in Section 5. We discuss policy issues in the final section.

2. Conceptual Framework and Modeling Approach

In this section, we present the conceptual framework that guides our analysis and describe our modeling approach. The conceptual framework shows the range of factors affecting birthweight and organizes them into a logical arrangement. It helps us to identify specific variables to include in our analysis and to recognize factors that are unmeasured or unmeasurable. Our modeling approach operationalizes the conceptual framework and tackles several potentially important methodological issues.

Our conceptual framework for analyzing the covariates of birthweight is presented in Figure 1. It is organized, left-to-right, from the distal to the proximate determinants. The outcome, birthweight, appears on the far right. Among the distal or background factors, few affect birthweight directly. Rather, they generally operate through the proximate or intermediate factors shown in the center of the figure.

The various factors covered in the conceptual framework are also organized from top to bottom according to the level at which they operate or are manifested. Child-specific factors appear at the top, mother, family or household factors in the middle, and community factors at the bottom. The boxes with the solid lines for borders represent the measured variables (described in Section 4 in more detail). Boxes with dashed lines for borders identify factors that

are unmeasured but potentially measurable. Finally, the shaded boxes represent unobserved factors that cannot be measured easily.

Child sex is our only child-specific background factor. It is well documented that males have higher birthweights than females. Unmeasured child-level factors include various dimensions of the health of the specific pregnancy. Below we explain why and how unmeasured factors may affect our analysis.

Relevant measured background characteristics of the mother and family include the mother's age, race and ethnicity, education, nativity, and marital status. As discussed below, a key variable that is unavailable from vital statistics is household economic status. Finally, many aspects of the mother's inherent healthiness are not measured and cannot be measured satisfactorily. This includes, for example, her genetic endowment that either predisposes or protects her—and her child—from adverse health outcomes.

There is a potentially large group of neighborhood- or community-level factors that might affect birthweight.⁴ The existing literature on this topic, although growing, is at present relatively small primarily because few data sets with information on birth outcomes also include, or can be linked with, data at the neighborhood level. We included no neighborhood level factors in our models. This is because their inclusion would distract from the main goal of this paper, which is to examine race and ethnic disparities in birthweight. Nevertheless, we believe

⁴ Previous research has examined the effects of various demographic, social and economic characteristics of neighborhoods on birth outcomes (Collins and David, 1997; O'Campo et al., 1997; Roberts, 1997; Pearl, Braveman, and Abrams, 2001; Rauh, Andrews and Garfinkel, 2001). Neighborhood demographic factors have included the age, race, and ethnic composition of residents; social characteristics have included marital status and immigration status; and economic characteristics have included the proportion of the population falling below the poverty line, rates of welfare receipt, and home ownership levels.

that neighborhood factors *are* likely to be important. To reconcile these two perspectives, we included, separately for each tract, a single dummy variable. This variable captures the effects of all measured—and unmeasured—factors operating at the tract level and hence allowed us to control for the complete set of neighborhood variables, although it does not permit us to identify the specific aspects of neighborhoods that are important.⁵

Intermediate child- or pregnancy-specific risk factors include gestation length, interpregnancy interval, parity, and medical risk factors. Birthweight is closely tied to gestation length and it is essential to control for this because there are systematic differences in gestation length according to race and ethnicity. A pregnancy that occurs only a short duration after the previous one ended can tax the mother physically and nutritionally and lead to a baby with a lower birthweight. Parity may represent a similar cumulative process, but there may be benefits (such as experience) as well as costs to reaching higher parities. A variety of medical risk factors may directly affect birthweight.

Smoking and alcohol use are intermediate factors that represent longer-term health behavior choices of mothers. There is considerable evidence that smoking and alcohol use lead to lower birthweight and worsen other birth outcomes (Lundsberg, Bracken, and Saftlas 1997; Sprauve et al. 1999). Finally, use of health services represents mother-specific behavior that is also influenced by neighborhood level factors such as the availability of health care. We consider three specific dimensions of health service use: prenatal care, birth attendance, and place of delivery. Prenatal care has been hypothesized to be a key intermediate factor affecting

⁵ We used census tracts to represent neighborhoods. Census tracts are of moderate size and closely approximate social definitions of neighborhoods. There is no consequence to this choice if neighborhoods are in reality comprised of multiple tracts. However, it will matter if true neighborhoods have boundaries that bisect tracts or are smaller than tracts.

birth outcomes and, in particular, to be one that is amenable to policy intervention. However, evidence for the relationship between prenatal care and birthweight is inconsistent (Alexander and Korenbrot, 1995; Fiscella, 1995; Huntington and Connell, 1994). In particular, many studies have found greater prenatal care to be associated with *lower* birthweight and *worse* birth outcomes or for beneficial effects to be substantially underestimated (Frick and Lantz, 1996). These findings point to the ways in which unobservable pregnancy- or mother-specific characteristics can shape the nature of the relationship between certain intermediate characteristics and birthweight. It is unreasonable to conclude from this evidence that prenatal care is unassociated with or *reduces* birthweight. Rather, the observed association reflects the adverse selection among mothers who are experiencing a difficult pregnancy, or who are unhealthy, that leads them to obtain earlier and more intensive prenatal care.⁶ Our use of cross-sectional data unfortunately precluded us from addressing the problem of adverse selection (e.g., regarding use of prenatal care) or endogeneity (e.g., regarding neighborhood of residence).

Our conceptual framework suggests an analytical approach to disentangling the effects of race and ethnicity on birthweight. The starting point is to examine the gross differences in birthweight across race and ethnic groups. The next step is to remove the effects of neighborhood factors which, for the current analysis, we view principally as a nuisance. We did so by examining race and ethnic disparities in birthweight with a model that included a control solely for tract of residence. We then began a more systematic analysis of the background and intermediate factors identified in the conceptual framework. We first estimated models that

⁶ Mismeasurement of the number of prenatal visits and the timing of prenatal care may lead to downward bias in the estimated effects of prenatal care on birthweight (Penrod and Lantz, 2000). Penrod and Lantz (2000) noted that birth certificate reports of prenatal care, which we used, provided the best source of information.

looked at the effects of background factors alone. The results from these models show the gross effects of background factors while controlling for other background factors but none of the pathways or intermediate factors through which background characteristics affect birthweight. The next step was to add intermediate factors to the previous model. These results reveal how these intermediate factors affect birthweight. They also shed light on ways in which the background factors affect birth outcomes. In particular, by examining differences in the effects of background factors between this model and the previous one, we learn the extent to which the intermediate factors included in our models account for the gross effects.

Our first set of results show the disparities in birthweight by race and ethnic group—as well as the factors that account for these disparities—based on models using data that were pooled across the different groups. This approach has the advantage of providing a simple and clear way to examine the gross and net effects of race and ethnicity. In particular, the disparity in birthweight between the (omitted) baseline group and any other race and ethnic group is represented by the coefficient on a dummy variable. This coefficient can be read directly from a table of results and is straightforward to understand and interpret. A shortcoming of the pooled data approach, however, is that it constrains the effects of all covariates to be identical for all the different race and ethnic groups. Imposing this structure on the model may be wrong and potentially misleading if the effects of covariates are substantially different across race and ethnic groups. One solution would be to estimate models that allow for certain covariate effects to vary by race and ethnicity through the use of interaction effects. A more general approach is to stratify the data and estimate separate models for the different groups. The results from the stratified model are equivalent to those from a model that includes the full set of interaction effects involving race and ethnicity, although the former model is simpler to understand and

interpret. However, it is not straightforward to summarize disparities in birthweight that remain after controlling for the included covariates using either of these models. To do this we draw instead on a simple decomposition of birthweight disparities that separates the total difference into two components, with the first component representing the contribution of differences in *characteristics* and the second component representing the differences the *effects* of any given set of characteristics. This decomposition in essence constructs a counterfactual case that estimates what the mean birthweight for one group (e.g., non-Hispanic whites) would be if they had their own characteristics but the relationship between these characteristics and birthweight that prevailed for another group (e.g., non-Hispanic blacks).

3. Statistical Methods

We used linear regression models to estimate the effects on birthweight of the factors discussed above. There are several methodological issues that we addressed and we discuss each of these in turn.

We modeled birthweight as a continuous outcome, in contrast to most—but not all—of the previous literature which has used a dichotomous variable that distinguishes low birthweight (<2,500 grams) from normal birthweight and logistic regression techniques.⁷ We did so because a tremendous amount of information is discarded in the process of converting a continuous variable into a dichotomous one. This is problematic because it results in a loss of statistical power to estimate covariate effects with precision, which it makes it more difficult to uncover true relationships that are present in the data.

⁷ Examples of recent studies analyzing birthweight as a dichotomous outcome include Roberts (1997), O’Campo et al. (1997), and Zhu et al. (1999). Among studies examining birthweight as a continuous outcome are David and Collins (1997), Pearl, Braveman, and Abrams (2001), and Shiono et al. (1997).

Although the cut-off of 2,500 grams is a meaningful in certain ways, in others it is arbitrary. As Rose (1992) notes, disease is nearly always a quantitative rather than a categorical phenomenon and hence has no natural definitions. The sharp distinction provided by the contrast of low birthweight with normal birthweight is in many ways a medical artifact. In particular, any increase in birthweight generally leads to better health and development outcomes, though the benefits are relatively large below 2,500 grams. This is illustrated in Figure 2, which shows the relationship between birthweight and infant mortality risk for Chicago in 1990 based on the vital statistics described below. This figure demonstrates first of all why birthweight is important: throughout virtually its entire distribution, higher birthweight is clearly associated with lower infant mortality risks.⁸ The rise in infant mortality risks at the high end of the birthweight distribution suggests that increases in birthweight may not be always be beneficial.⁹

We incorporated tract-level fixed effects in our models to capture the effects of all factors influencing birthweight that were common to births occurring in the same neighborhood. These factors include measurable and unmeasurable neighborhood characteristics as well as individual level attributes that are shared among all mothers in the same tract. Most prior studies (e.g.,

⁸ Wilcox (2001) raises the important point that a unit increase in birthweight may not have the same effects on infant mortality risks across the three ethnic groups, given their different birthweight distributions. However, it is not clear whether this extends to other important outcomes that are also of interest, such as measures of development and other health outcomes—particularly those in later childhood and in the adult years. Given this uncertainty, we decided not to analyze birthweight normalized by ethnic group, the approach Wilcox suggests.

⁹ The rise in mortality risks for birthweights above 4,750 grams is the result of birth trauma (Spellacy et al., 1985) and congenital anomalies and congenital syndromes such as hypoglycemia that are often associated with gestational diabetes (Jones, 2001). However, relatively few babies are born with birthweights this high. In Chicago in 1990, less than four-tenths of one percent of babies had birthweights above 4,750 grams.

Collins, Schulte, and Drolet, 1998; Roberts, 1997; Pearl, Braveman, and Abrams, 2001; O'Campo et al., 1997) have only partly adjusted for neighborhood characteristics through the incorporation of measured community-level variables. This is necessarily true because the array of community level variables available through the decennial census or most other data sources is limited. Controlling for omitted neighborhood variables through the use of fixed effects also provides a way to account for the correlation among birthweights in the same tract that would otherwise result in standard errors for parameter estimates being understated. Fixed effects models represent a specific alternative to the multilevel modeling approach that is growing in popularity among studies in public health, sociology, and other disciplines (Goldstein, 1995). In particular, multilevel models are based on the incorporation of random effects (at one or more levels) that absorb level-specific errors. However, an important assumption behind standard multilevel models is that the random effects are independent of the measured covariates that appear in the model. This assumption may be violated quite commonly. However, few researchers test this assumption, although a straightforward statistical test, developed by Hausman (1978), is available. In contrast, fixed effects models provide a simple means to control for the possible correlation between these unmeasured effects and the covariates that appear in the model by including a separate dummy variable for each tract represented in the data. To the extent that this correlation is present and important, it means that random effects models, in contrast to fixed effects models, lead to biased and inconsistent parameter estimates.¹⁰

The fixed effects approach was a better choice for our analysis because a series of formal Hausman tests comparing this approach to the random effects approach consistently rejected the assumption on which the random effects model is based (namely, that the regressors and the

¹⁰ Random effects models provide more efficient estimates, and hence are preferred, when correlation between the unobserved effects and measured covariates is unimportant.

random tract-level effect are uncorrelated). The main disadvantage of a fixed-effects approach is that it precludes our being able to include neighborhood-level variables in the models. However, examining the effects of specific neighborhood-level factors is not a goal of this paper.

An additional complication in studies such as ours that analyze data from contiguous neighborhoods is the potential for spatial correlation. Similarities, or interactions, between neighboring areas could lead to spatial correlation in the error terms. Standard errors that do not take this correlation into account may be understated, leading possibly to incorrect statistical inference. However, the fixed effects capture not only tract-specific factors, but also correlation among tracts. Thus the fixed effects approach removes much of the problem of spatial correlation. Finally, we report heteroscedasticity-consistent standard errors (estimated via the Huber/White/sandwich procedure) that should also diminish the effects of any remaining spatial correlation.

4. Data and Setting

The data for our study are based on individual birth certificate records for all births in 1990 that occurred to mothers who resided in the city of Chicago, Illinois.¹¹ The size and diversity of Chicago and the large health disparities found there make this city an interesting and important setting for our research. Chicago is the third largest city in the United States (U.S. Census Bureau, 2001a). It has the second largest African American and third largest Hispanic populations in the country (U.S. Census Bureau, 2001b, 2001c). Furthermore, Chicago has a large number of immigrants, half of whom originate in Central or South America (U.S. Census

¹¹ Mothers from suburban locations who gave birth in Chicago hospitals are excluded. Virtually all (99.3 percent) births to Chicago-resident mothers in 1990 occurred in Cook County; the remainder occurred in contiguous counties, with a small number occurring outside Illinois (primarily in Indiana).

Bureau, 2001d).

There were 60,242 live births to Chicago-resident mothers in 1990. For our analysis, we used information on 49,104 singleton births with complete information that were born to mothers who were non-Hispanic white (12,918 births), non-Hispanic black (26,005), or Mexican-origin Hispanic (10,181). We excluded all 1,530 multiple births (2.5 percent of total) because they differ systematically from singleton births and the approximately 3,235 of births (5.4 percent of total) that were missing key variables (such as birthweight or mother's race and ethnicity). We also excluded 6,373 births to mothers of other race and ethnic groups. The majority of these births (4,440) were to non-Mexican Hispanics, principally mothers from Puerto Rico (2,808) and Central and South America (881). We focused on the three largest race and ethnic groups because the sizes of the remaining groups were substantially smaller and preliminary findings suggested that the different groups could not be pooled.

A key feature of these data is that the residential address of the mother was geocoded—that is, the latitude and longitude coordinates specifying the exact location of the residence were calculated and assigned to each record. The geocoded address was used to determine the census tract of residence.¹² Approximately 99 percent of addresses were successfully geocoded with a valid census tract identifier.

The 1989 revision of the U.S. Standard Certificate of Live Birth collects a considerable amount of information on the pregnancy, the birth, and demographic characteristics of the

¹² The data were geocoded by the Chicago Department of Public Health. The Illinois Department of Public Health also created a database with geocoded birth records. However, we relied on the Chicago Department of Public Health database because its geocoding was more accurate. In particular, geocoding errors affecting as much as 10 percent of all Chicago birth records for the period 1989-1996 were discovered in the birth record files from the Illinois Department of Public Health.

mother (see National Center for Health Statistics, 1999). Pregnancy-related information includes live-birth order and parity, preceding birth interval, gestation length, prenatal care, tobacco and alcohol use during pregnancy, weight gained, medical risk factors, and obstetric procedures. Birth information includes birthweight, place of delivery, method of delivery, and delivery attendant, Apgar score, complications of labor and delivery, abnormal conditions of the newborn, and congenital anomalies. Finally, information on the mother includes her race and ethnicity, national origin, age, educational attainment, and marital status. There is no information from the birth certificate on the economic status of the mother or her household. The certificate asks about the father's characteristics, such as his age, race/ethnicity, place of birth, and education, but missing data is a major problem. Information contained in birth certificates is largely retrospective and hence may be misreported. Although this is unlikely for certain characteristics, such as education, it is more likely for use of alcohol, tobacco, and illicit substances. Validation studies suggest that birth weight is recorded very reliably on birth certificates (Buescher et al. 1993; Piper et al. 1993). Information on maternal medical risk factors, complications of labor and delivery, and conditions of the newborn appears to be somewhat less reliable (Adams 2001; Buescher et al. 1993; Piper et al. 1993). Although data on tobacco use during pregnancy appear to be more reliable than data on alcohol use, there is evidence that both behaviors are underreported on the birth certificate (Buescher et al. 1993; Piper et al. 1993).

Birthweight

The mean birthweight for the analysis sample was 3,236 grams (see Table 1). Non-Hispanic whites had a mean birthweight of 3,419 grams, while non-Hispanic blacks averaged 3,087 grams and Mexican-origin Hispanics' mean birthweight was 3,384 grams.

Although differences in average birthweights across the three groups were relatively

modest, they translated into substantial differences in low birthweight rates. For example, 13.4 percent of births to non-Hispanic blacks were of low birthweight (< 2,500 grams) which was almost three times higher than the rate among non-Hispanic whites of 4.8 percent.

Model Covariates and their Differences Across Race and Ethnic Groups

The covariates of birthweight that we examined were suggested by the conceptual framework outlined above and circumscribed by information contained in vital statistics for births. Although the specific covariates were similar to those used in previous studies, a number were coded differently and we highlight these differences in the brief overview of model covariates that we provide here. We also discuss similarities and differences in summary statistics for covariates across the three race and ethnic groups.

The list of covariates we examined appears in Table 2, along with the means for the three race and ethnic groups and the analysis sample as a whole. Background child and mother characteristics included child sex and mother's age, marital status, nativity, education, and race. For mother's education, Table 2 shows summary statistics for the number of years of schooling. In our models, however, we examined the effects of years of schooling beyond the eleventh grade. Our preliminary models suggested that it was reasonable to pool all mothers who had not completed high school as a single, homogenous group and then consider the linear effects of an additional year of education. This provided a good compromise between simplicity and obtaining a good fit to the data. In particular, it was much better than treating education as linear through its entire range or having a dummy variable comparing high school-graduates with non-high school graduates. The other background variables followed standard coding practices.

There were large differences between race and ethnic groups in mother's education, nativity, marital status, and age. Mexican-origin Hispanics had substantially lower levels of

education and were vastly more likely to have been foreign born. Mean years of education for Mexican-origin Hispanic mothers was 8.9 years, three years below that for non-Hispanic blacks and almost four and a half years below non-Hispanic whites. Over 80 percent of Mexican-origin Hispanics were foreign born, in contrast to 18 percent of non-Hispanic whites and fewer than two percent of non-Hispanic blacks. Non-Hispanic blacks stand out in terms of the percent of births to unmarried mothers, which at 82 percent were two-and-a-half times higher than the proportion for Mexican-origin Hispanics and over four times higher than for non-Hispanic whites. Non-Hispanic blacks had births at much younger ages than women in the other two groups.

Intermediate covariates included first birth status, interpregnancy interval, gestation length, adequacy of prenatal care, medical risk factors, tobacco and alcohol use, place of delivery, and birth attendant. The interpregnancy interval was modeled as a three-part linear spline¹³ that provided an excellent fit to the data—substantially better than treating this covariate as a categorical variable (for example, as in Rawlings, Rawlings, and Read, 1995 or Zhu et al., 1999). Our coding of this variable was based on a preliminary analysis that showed birthweight to have a very strong positive relationship with interpregnancy intervals when there was less than 12 months separating births, a moderate positive relationship for interpregnancy intervals between 12 and 59 months, and finally a weak negative relationship after 60 months. First births were set to the mean and were flagged using a separate covariate. Gestation length was also modeled as a spline, with a break at 41 weeks reflecting that birthweight increased with gestation length up to this point and declined beyond it. Information from the birth certificate on the

¹³ A spline is a piecewise function comprised of connecting linear segments. It provides a simple and straightforward approach to modeling non-linear relationships.

number of prenatal care visits and the month during the pregnancy that prenatal care began were recoded into Kotelchuck's (1994a and 1994b) Adequacy of Prenatal Care Utilization Index that included two parts. The first part provides an assessment of the timing of prenatal care initiation and the second part describes the frequency of visits received after initiation. In addition, we examined the effects of the number of prenatal care visits which was also modeled as a two-part spline with a knot at the mean of 14 visits. Information on 16 different medical risk factors during pregnancy was collected on birth certificates beginning in 1989. In our models we included a covariate indicating whether a woman had any medical risk factors because the quality of the information on any specific item is subject to reporting error.

Non-Hispanic whites generally had the most favorable set of intermediate factors relating to pregnancy and delivery. They had the lowest fertility rates, although they subsequently had shorter interpregnancy intervals. Almost half of births to non-Hispanic whites were first births, in contrast to around one-third of births for the other two groups. Non-Hispanic whites were far more likely to have had adequate or better prenatal care, according to both timing of initiation of care and the number of prenatal care visits. Approximately 90 percent of non-Hispanic whites had adequate or better prenatal care initiation, compared to three-quarters of non-Hispanic blacks and Mexican-origin Hispanics. Non-Hispanic whites reported a higher number of medical risk factors than the other two groups, although this may be related to the better prenatal care that they received.

Mexican-origin Hispanics had a number of highly favorable intermediate factors. Most notably, they had very low reported rates of smoking and alcohol use during pregnancy. Less than three percent of Mexican-origin Hispanic mothers reported smoking during pregnancy, compared to 17 percent of non-Hispanic whites and almost 20 percent of non-Hispanic blacks.

Half of one percent of Mexican-origin Hispanics reported consuming any alcohol during pregnancy; rates for non-Hispanic blacks and whites were roughly seven times higher, although non-Hispanic black mothers who drank reported an average of 2.4 alcoholic drinks per week compared to 1 drink per week by non-Hispanic white mothers who drank. Smoking and alcohol use during pregnancy was self-reported by mothers and hence may be subject to reporting biases. Mexican-origin Hispanics were less likely to have a medical risk factor (only 12 percent did) compared to non-Hispanic blacks (17 percent) or non-Hispanic whites (20 percent).

Similar across the three race and ethnic groups were place of delivery and birth attendant. Adequacy of prenatal care initiation was similar for non-Hispanic blacks and Mexican-origin Hispanics, although the latter group had more prenatal care visits. These two groups also had similar reproductive patterns, as reflected in the number of first births. Finally, non-Hispanic whites and Mexican-origin Hispanics had similar mean gestation length (of 39.2 weeks), while non-Hispanic blacks had a shorter mean length (38.5 weeks).

5. Results

Our results are presented in three subsections. In the first subsection, we present results for models estimated using data pooled across the three race and ethnic groups. We then present models estimated separately for each groups. Finally, we present a decomposition of race and ethnic differences in birthweight.

All our results are based on linear regression models described above. The parameter estimates show the effect on birthweight in grams of a one-unit increase in the explanatory variable for a continuous covariate or a one-category change, compared to the baseline group, for a categorical covariate. The tables of results include, for each parameter estimate, its standard error in parentheses and indicate the level of statistical significance.

Results from Models Estimated Using Pooled Data

We present our first set of findings in Table 3, which shows results for four different models of birthweight estimated using data pooled across all three race and ethnic groups. We begin by focusing on race and ethnic differences in birthweight across the four models. In Model I, which includes only a control for race and ethnicity, we recover the means from Table 1 and highlight the differences in birthweight between the baseline group (non-Hispanic blacks) and the other two groups (non-Hispanic whites and Mexican-origin Hispanics). The parameters in this model can be interpreted as the average difference in birthweight between non-Hispanic blacks and, say, non-Hispanic whites if we picked one non-Hispanic black birth and one non-Hispanic white birth from anywhere in Chicago. On average, we would find that non-Hispanic whites had birthweights 332 grams higher than non-Hispanic blacks. Birthweights for Mexican-origin Hispanics were only slightly lower than the average for non-Hispanic whites, but were substantially above those for non-Hispanic blacks.

The introduction of fixed effects for each census tract in Model II changes the nature of the comparison of birthweights across race and ethnic groups. In particular, by controlling for *all* measurable and unmeasurable neighborhood-level variables through the use of a tract-specific dummy variable, we are essentially examining birthweight disparities by race and ethnic group among births that occurred *in the same neighborhood*. We find that neighborhood factors accounted for 30 percent of the average birthweight disparity between non-Hispanic whites and non-Hispanic blacks; the difference in birthweight between these two groups is 231 grams in Model II, down from 332 grams in Model I. The birthweight disparity between non-Hispanic blacks and Mexican-origin Hispanics dropped 14 percent, from 297 grams to 255 grams. Fixed effects provide a nearly perfect control for neighborhood characteristics, although they provide

no insights into what specific neighborhood factors might be important. In addition, neighborhood effects in the model will pick up any observed or unobserved individual characteristics that were shared by all births in the same tract. Nevertheless, these results suggest that neighborhood factors played a significant role in explaining race and ethnic differences in birthweight.

Models III and IV introduce additional controls for background and intermediate characteristics. We interpret the coefficients for race and ethnicity in these models to be the average difference in birthweight among births in the same neighborhood after controlling for differences in mother's education, nativity, marital status, age, and child sex (Model III) and, in addition, birth order, interpregnancy intervals, gestation length, prenatal care, medical risk factors, smoking and alcohol use, place of delivery, and delivery assistance (Model IV).

We find from Model III that background factors accounted for 17 percent of the total birthweight differential between non-Hispanic blacks and non-Hispanic whites, while adding intermediate factors accounted for a further 17 percent of the differential. For the comparison between Mexican-origin Hispanics and non-Hispanic blacks, background factors explained 14 percent of the differential while intermediate factors explained an additional 30 percent. Model IV, which includes the full set of covariates, explained 64 percent of the birthweight differential between non-Hispanic blacks and non-Hispanic whites and 57 percent of the differential between Mexican-origin Hispanics and non-Hispanic blacks. Note, however, that the remaining unexplained birthweight differential is statistically significant at the .01 level for both comparisons (although the difference between non-Hispanic whites and Mexican-origin Hispanics is not statistically significant). Our results indicate that observed differences in a comprehensive set of covariates describing the mother's demographic and social characteristics,

as well as behaviors leading up to and during her pregnancy, accounted for a considerable part of the differences across race and ethnic groups—however, they did not explain it all. Roughly 36-43 percent of the differential between non-Hispanic blacks and the two comparison groups remains unexplained by the variables in our model.

Two sets of factors account for the unexplained portion of the differential. First, several potentially important covariates were not included in the model, because they were either not measured or had a large fraction of missing values. These include measures of the economic status of the mother and the household to which she belongs; background characteristics of the father; and indicators describing the healthiness of the mother (such as her height and her own birthweight). Although indicators of economic status and the mother's healthiness can be measured in principle, they are not collected on birth certificates. Information on fathers is collected on birth certificates, but missing data was a major problem. There are, in addition, unmeasurable child and mother factors—described in the conceptual framework—that we were unable to control for because we did not have multiple observations for each child or for each mother. Second, our models assume that the effects of all covariates on birthweight operate exactly the same way for each race and ethnic group. There are, however, good reasons to expect differences in covariate effects, at least for certain types of variables. For instance, there were substantial differences in marriage patterns across race and ethnic groups, reflecting in part the distinct types of marriage markets, competing prospects, and cultural constraints or opportunities that each group faced. These differences may also mean that being married was associated with different support arrangements across the groups, which in turn could translate

into marital status having varying effects on birthweight.¹⁴ This issue is important not only from a modeling point of view, but also with regard to policy implications of the findings. In particular, the pooled model implies that, from a policy perspective, efforts to reduce the birthweight gap across race and ethnic groups should focus on improving the *characteristics* of disadvantaged groups. However, allowing different covariate effects across the groups will tell us the extent to which *relationships* may be different, which may suggest an alternative set of interventions. We investigate this issue in more detail in the next subsection. In the remainder of this subsection we describe the results for the other covariates in our models.

There were positive effects on birthweight of infant sex, mother's education, and mother's marital status. Each year of education beyond eleventh grade was associated with a 20 gram increase in birthweight. Especially large effects were present for infant sex and mother's marital status. Females had birthweights 114 grams lower than males and children born to married mothers have birthweights that were 121 grams higher, on average, than those born to unmarried mothers. Mother's nativity was not associated with birthweight and the effects of mother's age, although negative and significant in Model III, switched signs in Model IV.

The background variables included in the models presented in Table 3 represent a range from purely biological (infant sex) to largely social (marital status). A comparison of the estimated effects of these background variables between Models III and IV show that a

¹⁴ To make this illustration more concrete, consider that non-Hispanic blacks may have lower birthweights than non-Hispanic whites not only because they have lower marriage rates (and knowing that, after controlling for other factors, children born to married parents have higher birthweights), but also perhaps because the beneficial effects of having a birth within a marriage are smaller for non-Hispanic blacks. This may occur, for example, because lower marriage rates mean that marriage is a weaker institution and hence fewer resources, less care, and limited information is provided to the mother by the husband.

substantial portion of the largely social variables is accounted for by the intermediate variables. For instance, birthweights for married women were 121 grams higher than those for unmarried women, when controlling for other background characteristics but no intermediate variables (Model III). Adding the intermediate variables (in Model IV) lowered the beneficial effect of being married by almost two-thirds. In contrast, there was no difference in the effect of infant sex between Models III and IV, since this variable does not operate through a behavioral pathway.

Among the intermediate variables, we find that first births have birthweights 100 grams lower than births of higher parity. Birthweights increased with interpregnancy intervals, with the effect especially strong for the first 11 months, then declining, and finally switching to a small negative effect after 60 months. Not surprisingly, gestation length had an exceptionally large effect. Our results indicate that one additional week of gestation was associated with a 150 gram increase in birthweight; only when gestation length exceeds 42 weeks does a negative effect appear. There were relatively small effects associated with the number of prenatal care visits while the timing of initiation was not statistically significant. Nevertheless, there was a clear positive association between a greater number of prenatal care visits and higher birthweight. The presence of one or more medical risk factors during the pregnancy was associated with a modest decline in birthweight. Finally, smoking and alcohol use during pregnancy were associated with large deleterious effects on birthweight that are highly significant. Smoking during pregnancy lowered birthweight by 163 grams while alcohol use was associated with a 94 gram drop.

Results from Models Stratified by Race and Ethnicity

Because there may be important differences in covariate effects across race and ethnic groups, we stratified the sample and reestimated the final two models from Table 3 separately for

non-Hispanic whites, non-Hispanic blacks, and Mexican-origin Hispanics. The results for the models including only background variables are presented in Table 4 while the results for the models that add intermediate variables are presented in Table 5. We focus our discussion on covariates whose effects differed substantially across race and ethnic groups. We do so because the stratified models (or models that interact these covariates with the race and ethnicity variables) provide unique substantive and policy insights only for these variables. Covariates effects that differed substantially by race and ethnicity include mother's age, education, and nativity, medical risk factors, and alcohol use.

There were relatively small differences by race and ethnicity in covariate effects for the remaining variables, including infant sex, mother's marital status, first births, gestation length, and cigarette smoking. Consequently, the simpler models presented in Table 3 that use data pooled across all race and ethnic groups would be fine for these variables. This is true even when there were dramatic differences in characteristics across race and ethnic groups. One example of this concerns the effects of mother's marital status. Results from the pooled model (Model III, Table 3) show that children born to married women had birthweights 121 grams higher than their non-married counterparts. When we estimated this relationship separately by race and ethnicity, we found (from Table 4) that the marriage effect was 155 grams for non-Hispanic whites, 132 grams for non-Hispanic blacks, and 76 grams for Mexican-origin Hispanics. Especially noteworthy is the relative similarity in the effects for non-Hispanic whites and blacks. This is remarkable because 80 percent of births to non-Hispanic whites occurred within marriages, *four times* the percentage among non-Hispanic blacks.

The effects of mother's age differed the most dramatically across race and ethnic groups. In contrast, differences in mothers' mean ages were much smaller, with non-Hispanics blacks

giving birth at the youngest ages (mean of 24 years), followed by Mexican-origin Hispanics at 26 years, and non-Hispanic whites at 28 years. However, the lower average ages translate into far higher teenage pregnancy rates among non-Hispanic blacks, which at 28 percent were roughly twice as high compared to Mexican-origin Hispanics (15 percent) and almost four times higher than non-Hispanic whites (7 percent). Mother's age was unrelated to birthweight for non-Hispanic whites. For non-Hispanic blacks, the age effect was negative and statistically significant: a one-year increase in age was associated with a 7-gram decrease in birthweight. Finally, for Mexican-origin Hispanics, age was positive and significant, with a one-year increment in age associated with a 10-gram increase in birthweight. Although these differences were not enough to account for much of the total birthweight disparity between non-Hispanic blacks and the other two groups, they certainly contributed towards it. The deleterious effects of age on maternal and child health for African Americans has been characterized as a form of rapid "weathering" that arises from their more difficult life circumstances (Geronimus, 1992).

Differences in the effects of mother's education were large across race and ethnic groups. Education had a statistically significant relationship with birthweight only for non-Hispanic whites and non-Hispanic blacks; for Mexican-origin Hispanics, education for women had extremely small (and insignificant) effects on birthweight. One additional year of education (beyond the eleventh grade) was associated with a 34 gram increase in birthweight for non-Hispanic blacks, an effect twice as high as that for non-Hispanic whites of 16 grams. However, the difference in mean years of education between non-Hispanic whites and non-Hispanic blacks was just over one year, substantially smaller than the difference in years of education between Mexican-origin Hispanics and non-Hispanic whites of 3.4 years. A possible reason for the substantially larger effect of education for non-Hispanic blacks is that they face a more

challenging environment to navigate in order to achieve a healthy pregnancy and birth, due to disadvantage and discrimination, and education provides women with the knowledge and ability to navigate these environments more successfully.

There was no difference in birthweight between native born and foreign-born Mexican-origin Hispanics after adjusting for background characteristics, in contrast to previous studies that were unable to account entirely for higher birthweights among foreign-born Mexican-origin Hispanics (e.g., Landale, Oropesa, and Gorman, 1999). However, non-Hispanic black immigrants had substantially higher birthweights than non-immigrants. This is likely to be related to the selectivity of these two groups, compared to their native-born co-ethnics. Under 2 percent of non-Hispanic blacks were foreign born, in contrast to 81 percent of Mexican-origin Hispanics. The small immigrant stream of non-Hispanic blacks was likely to have been more select, in terms of both observed and unobserved characteristics, than the huge stream of Mexican-origin Hispanics. For non-Hispanic whites, foreign-born mothers had slightly lower birthweights.

We turn next to Table 5, which presents results for models that include intermediate factors. We focus on two sets of findings. First, we discuss changes in the effects of the background variables (comparing these results to those in Table 4). Second, we discuss the effects of the intermediate factors, highlighting again similarities and differences across the three ethnic groups.

As expected, the effects of the background variables were again attenuated in almost every instance once we incorporated intermediate factors into the models. There were, however, essentially no statistically significant effects rendered insignificant, although some of the effects changed substantially. In particular, by including the intermediate factors, we accounted for a

large portion of the effect of education (for non-Hispanic whites and blacks), of mother's nativity (for non-Hispanic blacks), marital status (for all three groups), and mother's age (especially for non-Hispanic blacks). The largest and most consistent changes occurred for marital status. The intermediate factors in our models accounted for roughly two-thirds of the birthweight advantage experienced by children of married mothers. This suggests that married women generally practiced health-related behaviors during their pregnancy that were beneficial for their babies, such as not smoking nor consuming alcohol. The other notable change is that the effect of mother's age for non-Hispanic blacks was attenuated substantially and is only significant at the .10 level after controlling for the intermediate factors. This suggests that older non-Hispanic black mothers had less favorable pregnancy-related behaviors than younger mothers; once these behaviors were taken into account, mother's age had a minor effect on birthweight (as was the case for non-Hispanic whites).

Intermediate variable effects that were similar across the three race and ethnic groups included first birth, interpregnancy interval, gestation length, and smoking. Substantial differences were observed for medical risk factors, alcohol use, and place of delivery. A number of the intermediate variables did not have significant effects. For example, few of the indicators regarding prenatal care were statistically significant.

For the three intermediate variables for which there were substantial differences in effects across the groups, the only statistically significant effects were for non-Hispanic blacks. For this group, the deleterious effects of having a medical risk factor, using alcohol during pregnancy, or having a non-hospital delivery were large, even though in all three cases there were minor differences in levels compared to non-Hispanic whites. This suggests a source of disadvantage for non-Hispanic blacks that may reflect either more serious medical risk factors, more damaging

patterns of alcohol use, poorer delivery assistance, or worse treatment for medical risk factors. The absence of clear effects for prenatal care may have been caused by adverse selection (i.e., women who anticipated problems with a pregnancy may have initiated earlier prenatal care) or other factors. However, there is some evidence that adequacy of prenatal care visits was associated with higher birthweight.

Decomposing Race/Ethnic Differentials in Birthweight

The final task is to summarize the differences in birthweight across the three race and ethnic groups and, in particular, to identify the extent to which the measured background and intermediate covariates accounted for observed differences. In Table 6 we present a decomposition of birthweight differences among the three groups. The entries along the diagonal show observed values. The off-diagonal elements describe the counterfactual associated with a model (identified by the column) and a set of characteristics (identified by the row). For example, the top right entry in the table shows the predicted mean birthweight for non-Hispanic whites if the effects of their (background and intermediate) characteristics on birthweight were the same as for Mexican-origin Hispanics. The difference between this value (3,417.4) and the actual value for non-Hispanic whites (3,418.5) reflects overall differences in relationships—which are minor. The difference compared to the actual value for Mexican-origin Hispanics (3,383.8) reflects differences in characteristics—which in this case accounts for essentially the entire differential in birthweight between these two groups. Thus, the results indicate that the background and intermediate factors in the models account for all the birthweight difference between non-Hispanic whites and Mexican-origin Hispanics. The result is symmetric, in that we reach the same conclusion when examining predicted mean birthweight for Mexican-origin Hispanics using estimated relationships for non-Hispanic whites.

Measured characteristics account for just over half of the birthweight gap between non-Hispanic blacks and whites. Of the 331.7 gram difference in birthweight between non-Hispanic blacks and whites, 51 percent is accounted for by measured characteristics based on the model for non-Hispanic whites and 55 percent based on the model for non-Hispanic blacks. That leaves 44-49 percent that is accounted for by differences in the ways that the measured characteristics affect birthweight, as well as omitted variables.

Comparing non-Hispanic blacks and Mexican-origin Hispanics, we find that the results differ based on which model is selected as the standard (note, however, that the standard errors of the counterfactual estimates are large). Of the 297.0 gram difference in birthweight between these two groups, 66 percent is accounted for by differences in characteristics when using the non-Hispanic black model while 44 percent is accounted for when the Mexican-origin Hispanic model is used. The higher percentage explained by the non-Hispanic black model is due to this model's substantially better fit. In particular, the non-Hispanic black model has an adjusted R^2 of .48—indicating that this model explained roughly half the variation in birthweight for non-Hispanic blacks. In contrast, the model for Mexican-origin Hispanics has an adjusted R^2 of .30. The implication, however, is that there is a fairly large confidence interval in attributing this race/ethnic gap in birthweight between characteristics and relationships. Nevertheless, it is clear that differences in characteristics do not explain the entire differential between non-Hispanic blacks and Mexican-origin Hispanics.

Overall these results suggest that the disadvantage in birthweights for infants born to non-Hispanic black mothers—compared to non-Hispanic white and Mexican-origin Hispanic mothers—was not simply the result of non-Hispanic blacks being more disadvantaged according to their (measured) social characteristics and reproductive behaviors. Rather, there were

significant differences in birth outcomes between non-Hispanic blacks and the other two groups when the characteristics of the mother and the pregnancy were set at exactly the same values, with non-Hispanic blacks faring substantially worse. This may be the result of the omission of important covariates—such as household income or measures of maternal stress or health status. However, it also suggests that, for non-Hispanic blacks, not only were the effects of demographic, social, and reproductive factors overall less beneficial for the positive factors and more deleterious for the negative factors (as we showed above), but that the consequences for birthweight of these differences were large.

6. Conclusions

The goal of this study was to examine differences in birthweight across race and ethnic groups in Chicago, Illinois in 1990. Specifically, our analyses addressed three questions. First, what proportion of racial and ethnic birthweight disparities is explained by differences in maternal characteristics and health and reproductive behaviors? Second, what proportion of these disparities is explained by differences in the *effects* of these characteristics or behaviors on birthweight? Third, what proportion of racial and ethnic birthweight disparities are accounted by neighborhood factors?

We found that measured characteristics accounted for about half of the birthweight gap between non-Hispanic whites and blacks (of 332 grams) and between non-Hispanic blacks and Mexican-origin Hispanics (of 297 grams). In both cases, the remainder was accounted for by differences in variable effects or unmeasured variables. This result has important implications for policies and programs to improve birthweight and to eliminate race and ethnic disparities in infant health. In particular, it suggests that it is not enough simply to provide non-Hispanic black women with more advantageous characteristics, such as better education and access to medical

care. Although this might eliminate roughly half of the current disparity in birthweight, it would not, however, be sufficient to erase it entirely. Rather, more significant structural changes are required—changes that would alter the way in which mothers' characteristics and behaviors affect birth outcomes.

The principal differences in characteristics that led to low birthweight among non-Hispanic black mothers were their lower levels of education, higher rates of non-marital births, less adequate prenatal care, higher rates of smoking and, especially, shorter gestation lengths. A number of factors had distinct effects for non-Hispanic blacks compared to the other two groups, including mother's age, mother's education, medical risk factors, and alcohol use. Policy interventions to improve birthweight among non-Hispanic blacks need to focus on both sets of factors in order to eliminate race and ethnic disparities. Policies designed to alter mothers' characteristics are fairly easy to design and implement, but ones aimed at changing relationships are more difficult to conceptualize, let alone implement.

One reason that relationships may differ—for example, that the effects of medical risk factors have a strong negative effect on birthweight only for non-Hispanic blacks—is that the underlying factor is actually different across the race/ethnic groups. For example, given the same risk factor, non-Hispanic blacks may suffer from worse forms of the disease or condition. Better measurement of these factors may be the solution to this problem. However, another reason that relationships may vary is that processes may differ fundamentally across the race/ethnic groups. For instance, non-Hispanic blacks may, due to a variety of reasons, may receive poorer health care for their risk factors, although the actual type and severity of the disease or condition is no different than that for either of the other two groups. Both of these issues should be investigated in order to develop a better understanding of race and ethnic

differences in birthweight and to design policies to eliminate them.

Mexican-origin Hispanics in Chicago had remarkably good birth outcomes, despite their apparent socioeconomic disadvantage. Among the specific factors that contributed to Mexican-origin Hispanics having such favorable birth outcomes were their lower levels of smoking and alcohol use and their lack of medical risk factors. In addition, they had very similar gestation lengths to non-Hispanic whites. Our results suggest that although their mean birthweight was slightly lower than that for non-Hispanic whites, differences in the levels of measured covariates accounted for all of this difference. There are a number of clear changes that might be pursued from a policy perspective to improve birthweight among Mexican-origin Hispanics. These include increasing mothers' ages at birth and reducing non-marital births.

Our results suggest that neighborhood factors are important in explaining differences in birthweight, accounting for 14 percent of the raw differential between non-Hispanic blacks and Mexican-origin Hispanics and as much as 30 percent of the raw differential between non-Hispanic blacks and whites. This is a particularly noteworthy result given the persistent and striking spatial variation in the social, economic, and health characteristics of urban populations. In on-going research we are investigating the specific neighborhood factors that account for this finding.

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Table 1. Summary birthweight statistics by race/ethnicity for Chicago, 1990

	Race			Total
	Non-Hispanic Whites	Non-Hispanic Blacks	Mexican-origin Hispanics	
Birthweight (grams)				
Mean	3,418.5	3,086.8	3,383.7	3,235.7
Standard deviation	568.7	628.9	546.4	617.7
Low birthweight (< 2,500 g)	4.8%	13.4%	4.4%	9.1%
Very low birthweight (< 1,500 g)	0.9%	2.7%	0.8%	1.7%
Number of observations	12,918	26,005	10,181	49,104

Source: Authors' calculations from Chicago birth certificate data.

Table 2. Means (and standard deviations) or percent by category for independent variables by race for Chicago, 1990

Variable	Race			Total
	Non-Hispanic whites	Non-Hispanic blacks	Mexican-origin Hispanics	
Infant sex				
Male	51.1%	50.5%	51.6%	50.9%
Female	48.9	49.5	48.4	49.1
Mother's education (years)	13.3 (2.6)	12.0 (1.7)	8.9 (3.4)	11.7 (2.8)
Mother's nativity				
U.S. born	81.8%	98.2%	18.8%	77.4%
Foreign born	18.2	1.8	81.2	22.6
Mother's marital status				
Not married	19.8%	82.0%	33.8%	55.6%
Married	80.2	18.0	66.3	44.4
Mother's age (years)	28.3 (5.7)	23.9 (5.9)	25.5 (5.7)	25.4 (6.1)
First birth				
No	53.4%	64.6%	64.2%	61.6%
Yes	46.6	35.4	35.8	38.4
Pregnancy interval^a (months)	34.9 (33.7)	37.7 (39.3)	37.6 (32.7)	37.0 (36.7)
Gestation length (weeks)	39.2 (2.1)	38.5 (2.8)	39.2 (2.1)	38.8 (2.5)
Adequacy of prenatal care initiation				
Inadequate	4.4%	10.5%	7.7%	8.3%
Intermediate	6.4	14.2	13.2	12.0
Adequate	22.3	34.9	32.3	31.0
Adequate plus	66.9	40.5	46.8	48.8
Adequacy of prenatal care visits				
Inadequate	5.7%	14.0%	8.7%	10.7%
Intermediate	19.9	28.9	28.0	26.4
Adequate	51.7	31.3	42.6	39.0
Adequate plus	22.8	25.9	20.7	24.0
Number of prenatal care visits	11.1 (4.5)	9.2 (5.0)	9.7 (4.7)	9.8 (5.4)
Prenatal care information missing				
No	98.4%	98.2%	98.1%	98.3%
Yes	1.6	1.8	1.9	1.7
Medical risk factors				
None	80.5%	83.0%	87.6%	83.3%
Any	19.5	17.0	12.4	16.7
Smoked during pregnancy				
No	82.6%	80.4%	97.3%	84.5%
Yes	17.4	19.6	2.7	15.5
Cigarettes per day^b	16.2 (11.2)	13.9 (12.5)	13.2 (13.6)	14.5 (12.2)
Alcohol use during pregnancy				
Some	3.3%	3.5%	0.5%	2.8%
None	96.7	96.5	99.5	97.2
Alcoholic drinks per week^c	1.0 (2.2)	2.4 (4.5)	1.0 (1.7)	1.9 (3.9)
Place of delivery				
Hospital	99.0%	98.9%	99.8%	99.1%
Other	1.0	1.1	0.2	0.9

(Continued)

Table 2. *Continued*

Variable	Race			Total
	Non-Hispanic whites	Non-Hispanic blacks	Mexican-origin Hispanics	
Birth attendant				
Medical person	94.2%	92.6%	91.7%	92.8%
Midwife	2.8	1.3	2.3	1.9
Other	3.1	6.1	6.0	5.3
Number of observations	12,918	26,005	10,181	49,104

Source: Authors' calculations using 1990 Chicago vital statistics data.

Notes: a. Among women with a prior live birth.

b. Cigarettes per day among women who smoked during pregnancy.

c. Alcoholic drinks per week among women who used alcohol during pregnancy.

Table 3. Regression models showing the effects of neighborhood and individual characteristics on racial/ethnic differentials in birthweight

Variable	Model I	Model II	Model III	Model IV
Infant sex				
Male ^a
Female	.	.	-113.6*** (5.4)	-116.9*** (4.1)
Mother's race				
Non-Hispanic white	331.7*** (6.4)	230.6*** (13.0)	174.9*** (13.2)	119.4*** (10.2)
Non-Hispanic black ^a
Mexican-origin Hispanic	296.9*** (7.0)	255.2*** (12.9)	214.5*** (14.7)	126.2*** (11.4)
Mother's education^b (years)				
	.	.	19.7*** (2.0)	8.4*** (1.6)
Mother's nativity				
U.S. Born ^a
Foreign Born	.	.	3.3 (10.0)	-17.9* (7.7)
Mother's marital status				
Not married ^a
Married	.	.	120.8*** (7.3)	45.4*** (5.7)
Mother's age (years)				
	.	.	-1.5** (0.5)	1.2* (0.5)
First birth				
No ^a
Yes	.	.	.	-100.0*** (5.3)
Pregnancy interval (spline)				
0-11 months	.	.	.	7.7*** (1.2)
12-59 months	.	.	.	0.2 (0.2)
60+ months	.	.	.	-0.9*** (0.1)
Preceding birth interval missing				
No ^a
Yes	.	.	.	-43.2** (14.3)
Gestation length (spline)				
18-41 weeks	.	.	.	149.5*** (1.1)
42-50 weeks	.	.	.	-21.2** (7.1)
Adequacy of prenatal care initiation				
Inadequate	.	.	.	19.1 (11.5)
Intermediate	.	.	.	18.7* (8.7)
Adequate	.	.	.	-7.1 (5.3)
Adequate plus ^a
Adequacy of prenatal care visits				
Inadequate	.	.	.	-39.4*** (11.8)
Intermediate	.	.	.	-22.2*** (6.9)
Adequate ^a
Adequate plus	.	.	.	-2.0 (6.9)
Number of prenatal care visits (spline)				
0-14 visits	.	.	.	5.6*** (1.4)
15+ visits	.	.	.	1.2 (1.3)
Prenatal care information missing				
No ^a
Yes	.	.	.	75.0** (24.3)
Medical risk factors				
None ^a
Any	.	.	.	-19.7*** (5.7)

(Continued)

Table 3. *Continued*

Variable	Model I	Model II	Model III	Model IV
Smoked during pregnancy				
No ^a	.	.	.	.
Yes	.	.	.	-162.5*** (9.1)
Cigarettes per day^c	.	.	.	-0.7 (0.4)
Alcohol use during pregnancy				
Some ^a	.	.	.	.
None	.	.	.	-94.1*** (22.4)
Alcoholic drinks per week^d	.	.	.	2.7 (3.6)
Place of delivery				
Hospital ^a	.	.	.	.
Other	.	.	.	-60.5** (22.5)
Birth attendant				
Medical person ^a	.	.	.	.
Midwife	.	.	.	37.2* (15.3)
Other	.	.	.	-14.0 (9.4)
Constant	3,086.8*** (3.7)	3,122.1*** (6.2)	3,119.1*** (7.4)	3,530.7*** (36.3)
Model F-test (df)	1,727.3*** (2)	2,14.9*** (2)	1,94.6*** (7)	1,077.2*** (33)
Tract fixed effect	No	Yes	Yes	Yes
Adjusted R-squared	0.07	0.06	0.09	0.46
Number of observations	49,104	49,104	49,104	49,104

* $p < .05$; ** $p < .01$; *** $p < .001$; standard errors in parentheses.

Source: Authors' calculations using 1990 Chicago vital statistics data.

Notes: a. Reference category.

b. Years of schooling beyond the 11th grade.

c. Cigarettes per day among women who smoked during pregnancy.

d. Alcoholic drinks per week among women who used alcohol during pregnancy.

Table 4. Fixed effects regression of birthweight on exogenous characteristics by race/ethnicity

Variable	Race					
	Non-Hispanic whites		Non-Hispanic blacks		Mexican-origin Hispanics	
Infant sex						
Male ^a						
Female	-119.3***	(10.0)	-114.9***	(7.8)	-102.8***	(10.9)
Mother's education (years)	15.6***	(3.0)	33.7***	(3.3)	-1.3	(5.2)
Mother's nativity						
U.S. born ^a						
Foreign born	-35.6*	(14.0)	89.6**	(31.4)	-5.8	(15.4)
Mother's marital status						
Not married ^a						
Married	155.0***	(14.9)	131.5***	(11.4)	76.3***	(12.2)
Mother's age (years)	-0.8	(1.0)	-6.6***	(0.8)	9.5***	(1.0)
Constant	3,322.2***	(13.9)	3,070.0***	(7.1)	3,383.4***	(15.9)
Model F-test (df)	66.2***	(5)	106.9***	(5)	50.6***	(5)
Tract fixed effect	Yes		Yes		Yes	
Adjusted R-squared	0.03		0.02		0.02	
Number of observations	12,918		26,005		10,181	

* $p < .05$; ** $p < .01$; *** $p < .001$; standard errors in parentheses.

Source: Authors' calculations using 1990 Chicago vital statistics data.

Note: a. Reference category.

Table 5. Fixed effects regression of birthweight on endogenous and exogenous characteristics by race/ethnicity

Variable	Race					
	Non-Hispanic whites		Non-Hispanic blacks		Mexican-origin Hispanics	
Infant sex						
Male ^a	.	.	.	.	.	.
Female	-128.6***	(8.0)	-113.1***	(5.7)	-113.3***	(9.3)
Mother's education (years)	9.0***	(2.6)	13.9***	(2.5)	0.3	(4.5)
Mother's nativity						
U.S. born ^a	.	.	.	.	.	.
Foreign born	-36.4***	(11.5)	68.0**	(23.0)	-32.4*	(13.3)
Mother's marital status						
Not married ^a	.	.	.	.	.	.
Married	53.9***	(12.4)	55.4***	(8.5)	27.6**	(10.6)
Mother's age (years)	0.5	(0.9)	-1.5*	(0.7)	7.6***	(1.0)
First birth						
No ^a	.	.	.	.	.	.
Yes	-116.7***	(10.0)	-78.5***	(7.6)	-124.8***	(12.0)
Pregnancy interval (spline)						
0-11 months	2.3	(3.0)	7.9***	(1.6)	8.5**	(2.8)
12-59 months	0.6	(0.4)	-0.1	(0.3)	0.5	(0.4)
60+ months	-0.9**	(0.3)	-0.5**	(0.2)	-1.5***	(0.4)
Pregnancy interval missing						
No ^a	.	.	.	.	.	.
Yes	-31.1	(30.1)	-56.8**	(20.0)	-29.2	(28.4)
Gestation length (spline)						
18-41 weeks	163.4***	(2.7)	147.4***	(1.3)	142.6***	(3.1)
42-50 weeks	15.6	(15.6)	-34.2***	(9.3)	-24.3	(16.2)
Adequacy of prenatal care initiation						
Inadequate	-12.3	(29.1)	20.9	(14.4)	21.5	(27.6)
Intermediate	-19.1	(21.4)	20.0	(11.2)	16.8	(19.9)
Adequate	-2.5	(11.1)	-14.3*	(7.2)	-6.1	(11.8)
Adequate plus ^a	.	.	.	.	.	.
Adequacy of prenatal care visits						
Inadequate	-31.5	(28.8)	-31.0*	(14.8)	-47.8	(28.5)
Intermediate	-19.1	(15.0)	-16.5	(9.2)	-36.6*	(15.4)
Adequate ^a	.	.	.	.	.	.
Adequate Plus	-14.7	(13.5)	5.6	(9.6)	8.6	(16.5)
Number of prenatal care visits (spline)						
0-14 visits	1.8	(3.2)	6.8***	(1.9)	3.0	(3.6)
15+ visits	-0.4	(2.8)	2.0	(1.6)	-1.1	(3.5)
Prenatal care information missing						
No ^a	.	.	.	.	.	.
Yes	-2.5	(58.6)	72.5*	(29.9)	112.7	(64.8)
Medical risk factors						
None ^a	.	.	.	.	.	.
Any	9.4	(10.4)	-36.1***	(7.8)	-13.8	(14.5)
Smoked during pregnancy						
No ^a	.	.	.	.	.	.
Yes	-148.6***	(18.7)	-159.0***	(11.0)	-122.4**	(42.0)

(Continued)

Table 5. *Continued*

Variable	Race					
	Non-Hispanic whites		Non-Hispanic blacks		Mexican-origin Hispanics	
Cigarettes per day^b	-2.1*	(0.9)	0.1	(0.5)	-0.2	(2.1)
Alcohol use during pregnancy						
Some ^a	.	.	.	.	.	.
None	-25.8	(46.8)	-105.1***	(26.8)	-30.0	(245.9)
Alcoholic drinks per week^c	1.4	(12.3)	4.4	(3.9)	-66.2	(71.3)
Place of delivery						
Hospital ^a	.	.	.	.	.	.
Other	54.9	(42.0)	-109.0***	(27.9)	-85.4	(99.2)
Birth attendant						
Medical person ^a	.	.	.	.	.	.
Midwife	-0.2	(25.5)	42.3	(25.2)	61.9*	(31.2)
Other	-56.0*	(23.9)	5.3	(12.2)	-16.7	(19.8)
Constant	3,536.1***	(84.7)	3,498.9***	(46.7)	3,713.5***	(82.6)
Model F-test (df)	242.0***	(31)	738.0***	(31)	133.3***	(31)
Tract fixed effects	Yes		Yes		Yes	
Adjusted R-Squared	0.39		0.48		0.30	
Number of observations	12,918		26,005		10,181	

* $p < .05$; ** $p < .01$; *** $p < .001$; standard errors in parentheses.

Source: Authors' calculations using 1990 Chicago vital statistics data.

Notes: a. Reference category.

b. Cigarettes per day among women who smoked during pregnancy.

c. Alcoholic drinks per week among women who used alcohol during pregnancy.

Table 6. Decomposition of race/ethnic differences in birthweight based on fixed effects regression models with endogenous and exogenous characteristics

Group	Model		
	Non-Hispanic whites	Non-Hispanic blacks	Mexican-origin Hispanics
Non-Hispanic whites	3,418.5 ^a (3.9)	3,269.4 (7.0)	3,417.4 (13.0)
Non-Hispanic blacks	3,249.3 (8.7)	3,086.8 ^a (2.8)	3,253.9 (12.3)
Mexican-origin Hispanics	3,385.6 (9.4)	3,292.4 (18.9)	3,383.8 ^a (4.5)

Source: Authors' calculations using 1990 Chicago vital statistics data.

Notes: a. Actual observed value; standard errors in parentheses.

Figure 1. Conceptual Framework for Analysis of Birthweight

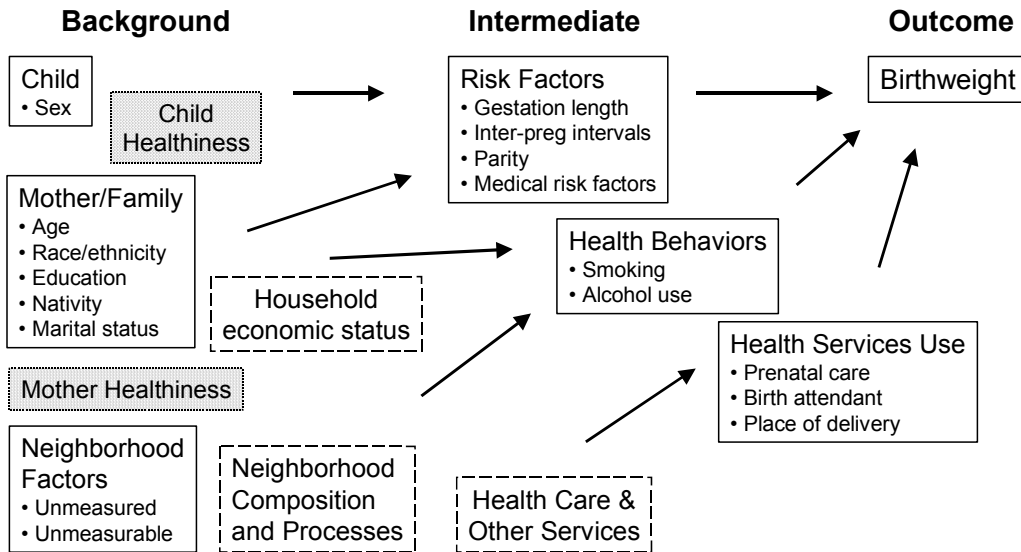
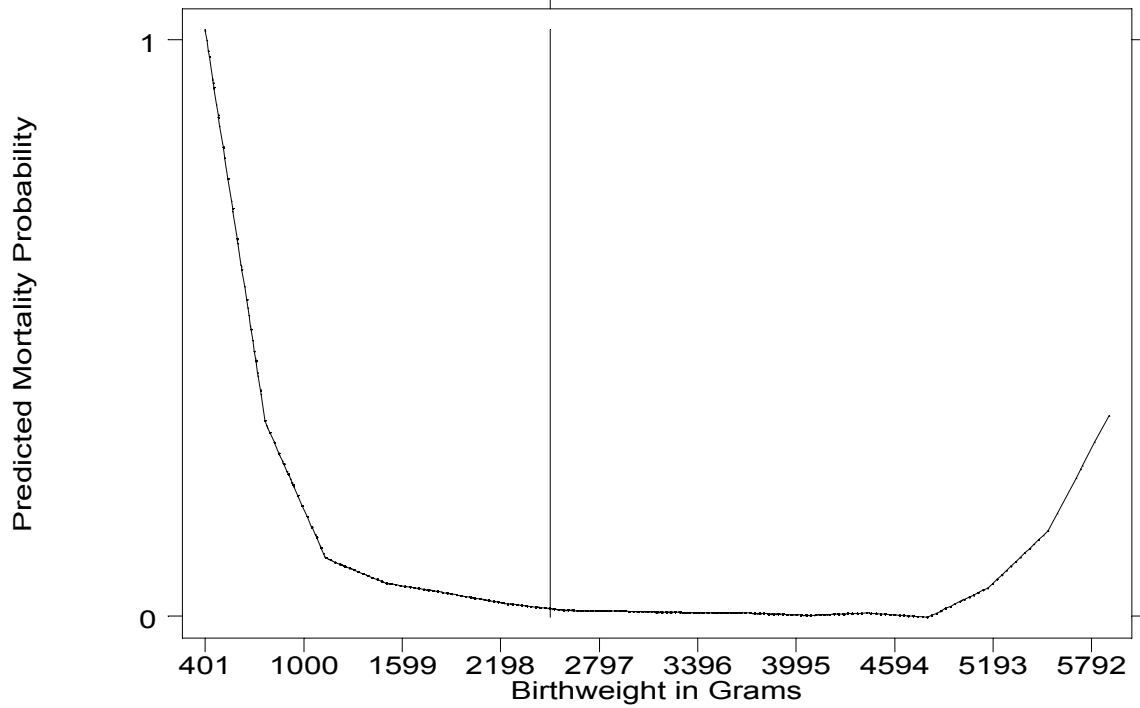


Figure 2. The Relationship Between Birthweight and the Risk of Infant Mortality Based on Vital Statistics for Chicago, IL, 1990



Note: Figure plots the predicted probability of death based on a linear probability mortality model for infant mortality with birthweight treated as a spline with 15 evenly spaced segments. The infant mortality rate for Chicago in 1990 was 12.5 per 1,000.