BI-RACIAL/ETHNIC INFANTS AND INFANT MORTALITY IN THE UNITED STATES*

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Objective. With the growing number of multiethnic persons in the United States, the validity of using only maternal race/ethnicity to categorize infants in studies of birth outcomes becomes questionable. We examine racial/ethnic disparities in infant mortality risk among bi-racial/ethnic groups as compared to their single-race/ethnic counterparts in the United States using the National Center for Health Statistics (NCHS) Linked Birth/Infant Death files from 1995-1998. *Methods*. Logistic regression models estimate infant mortality differentials across groups. *Results*. Clear differences in infant mortality risks are apparent by both maternal *and* paternal race/ethnicity. Some groups of mixed race/ethnic infants experience very low mortality, while others exhibit higher mortality than their single race/ethnic counterparts. Interestingly, infants for whom the race/ethnicity of father is unreported experience the highest risks of death among all combinations. *Conclusion*. Both maternal and paternal characteristics, including race/ethnicity, should be considered in studies of infant and child health.

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INTRODUCTION

Racial/ethnic disparities in pregnancy outcomes have become a forefront concern at the national level, and the urgency to identify causal factors underlying the differences has intensified in recent years. One of the basic indicators of not only the risk of adverse pregnancy outcomes, but also of population health, is the infant mortality rate (Eberstein 1989; Wise & Pursely 1992; Yankauer 1990; Hummer et al 1999). In the United States, the infant mortality rate (IMR) for African American (henceforth "Blacks") infants remains persistently higher than for non-Hispanic White infants (henceforth "Whites"), and the relative gap continues to widen (Singh and Yu 1995; Guyer et al 2000). While in 1915 the IMR for Whites was 100 per 1000 births, the IMR for Blacks was twice as high. Both groups experienced precipitous declines in infant mortality through the next eight decades. However, by 1998, Black infant mortality was more than twice that of Whites (14.3 and 6.0 for Blacks and Whites, respectively) (Guyer et al. 2000). Somewhat enigmatically, Mexican Americans exhibit an infant mortality level similar to Whites. This phenomenon is widely known as the "epidemiologic paradox" due to the relatively favorable health outcomes of Hispanic populations comparable to Whites, despite their shared disadvantaged socioeconomic conditions with Blacks (Markides and Coreil 1986; Palloni and Morenoff 2001).

While numerous studies investigate the infant health status of racial/ethnic groups (as determined by maternal race/ethnicity), only scant research considers mixed-racial/ethnic infants, perhaps due to the relatively small size of some of the maternal/paternal race/ethnic combinations. If taken as an aggregate, however, U.S. individuals who self-identify as multiracial are in-fact the 5th largest racial group (at 6.8 million people), outnumbering single-race groups such as American Indian/Alaskan Natives (2.4 million) and Native Hawaiian/Pacific Islanders (398,835) according to Census 2000 estimates (Census 2000 Profile 2002). It is important to note that such estimates do not take ethnicity into account; indeed, our figures below will show sizable numbers of children who are born to a Hispanic/non-Hispanic set of parents. Moreover, with a steady increase in the intermarriage rate, the proportion of mixed race/ethnic persons will rise even further. By the year 2050, under medium assumptions of immigration and intermarriage, Waters (2000) estimates that persons of multiple ancestry may comprise 21% of the population.

With the growing number of mixed ancestry persons, the validity of using only maternal race/ethnicity to categorize infants in studies of birth outcomes, and in national statistics, becomes questionable. Indeed, there exists a positive relationship between education level and intermarriage for most race/ethnic groups (Bernard 1966; Mare 1991; Qian 1997; Kalmijn 1993, 1998; Suro 1999; Jacobs and Labov 2002; Yancey 2002). This means that many children of mixed race/ethnic ancestries are a distinctive, advantaged group compared to their mono-racial/ethnic counterparts (Farley 2002). For example, Census 2000 data reveal that children with one Black parent and one White parent live in households having a median household income of $40,600, which lies in-between that of single-race White ($58,221) and single-race Black ($31,100) families, respectively (Farley 2002; also see Qian 1997; Farley 1999; Parker and Lucas 2000; Goldstein and Morning 2002; Harris 2002; Jacobs and Labov 2002; Wells 2003). The distinctiveness of mixed-racial/ethnic individuals on key socioeconomic characteristics is crucial to birth outcomes research since differentials by race and ethnicity are closely linked to socioeconomic status.

Past research on pregnancy outcomes of interracial births focus largely on Blacks and Whites, particularly on differences in birth weight. Most studies find that risks of low birth weight (LBW) and very low birth weight (VLBW) for biracial infants are unique from their single-race counterparts (Mangold and Powell-Griner 1991; Migone, Emanuel, Mueller, et al. 1991; Parker and Schoendorf 1992; Hessol, Fuentes-Afflick, and Bacchetti 1998; Parker 2000). Infants whose parents are both White tend to experience the most favorable birth outcomes, followed by infants of White mothers/Black fathers and Black mothers/White fathers, respectively. Single-race Black infants consistently have been shown to exhibit poorer birth outcomes than the above three groups. In short, the birth outcomes of biracial Black-White infants are intermediate between their mono-racial counterparts.

While a number of studies have investigated birth weight among bi-racial infants, just one study to date examines *infant mortality patterns* among bi-racial/ethnic infants. Using vital statistics data from New Mexico, Rogers (1989) investigates whether the lower observed infant mortality among Hispanics as compared to Whites is a fact or an artifact of how researchers code race and ethnicity. Rogers first stratifies infant mortality rates by race/ethnicity of the mother and of the father before amalgamating these groups into four possible ethnic coding schemes. The four ethnic coding schemes include: (1) a Hispanic ethnicity determinant, where only ethnicity of one parent determines the ethnicity of the infant, regardless of race; (2) a race and Hispanic ethnicity determinant, which is similar to the above, but also takes race into account; (3) a mother's ethnicity determinant, where ethnicity of the mother determines the ethnicity of the child; and (4) a father's ethnicity determinant. His analysis shows that infants with a Hispanic mother and a non-Hispanic White father have the lowest death rate at 6.6 per 1000 births, which was lower than both single-ethnic White infants (8.2) and single-ethnic Hispanic infants (8.1), respectively. Rogers concludes that, first, variation in infant mortality risk appears to depend on both the race/ethnicity of the mother and of the father. Second, depending on how ethnicity is coded, Hispanics can have mortality rates that are higher than or lower than non-Hispanic Whites. The reported differences, he concludes, is in part dependent upon the construction of child ethnicity rather than solely a characteristic of either the mother's or father's race/ethnic group. Nevertheless, national reports of birth outcomes and infant mortality—such as those presented annually by the National Center for Health Statistics (NCHS)—continue to rely solely on maternal reports of race/ethnicity.

Rogers' analysis provides an insightful demonstration of overall differences in infant mortality by both maternal and paternal race/ethnicity. However, substantial increases in mixed race/ethnic births since that time, as well as an increasing recognition in the demographic and sociological literature that the characteristics of both mothers *and* fathers are important for child well-being (Single-Rushton and McLanahan 2002; Clarke, Cooksey and Verropoulou 1998), leaves considerable opportunity for further investigation. The overall purpose of this study, then, is to expand on previous research by further exploring racial/ethnic differences in infant mortality with an emphasis of how inter-racial/ethnic mortality risks differ from their single-racial/ethnic counterparts. We expand upon the research in this area in three ways. First, moving beyond the calculation of the rates themselves, we consider whether demographic and social variables influence the infant mortality differentials between both single-race/ethnic and bi-race/ethnic infants. Second, we expand the geographic coverage of interest to the entire nation, rather than considering just one state. Third, we consider the three largest race/ethnic groups of childbearing women in the country—White, Black, and Mexican Origin—along with the race/ethnic identification of the fathers of these women, including a subset of fathers for whom there is no report of race/ethnicity.

DATA/METHODS

Data

We base this analysis on data from the 1995-1998 National Center for Health Statistics Linked Birth/ Infant Death files for the entire United States. These data are suitable for this analysis due to the expansive geographic coverage of these files—providing reliable data for relatively small subpopulations—and the inclusion of both maternal and paternal race/ethnicity from the birth certificates. A total of 15,627,407 records characterized the four years of data, including 2,617,139 observations for which father's race/ethnicity was unknown. Of the approximately 15 million births, 3.63% (or 567,029) were identified as bi-racial/ethnic in this study.

The birth certificate data provide the maternal and paternal race/ethnicity variables. Presumably, the mother reports both paternal and maternal race/ethnicity, since she is the usual informant on the birth certificate (Rogers 1989). This analysis uses 15 racial/ethnic categories by cross-classifying non-Hispanic Black, non-Hispanic White, and Mexican American mothers (3 categories) with non-Hispanic Black, non-Hispanic White, Mexican American, "other[1]" and "missing race/ethnicity" fathers (5 categories). Thus, infants born to women who were not Black, White, or Mexican Origin were excluded from the study. Further, not all possible racial/ethnic pairings could be considered. Indeed, the above combinations were chosen based on the size of the race/ethnic groups and a concern for at least some parsimony.

[1] "Other" includes fathers of Native American, Chinese, Japanese, Hawaiian, Filipino, Other Asian or Pacific Islander, Puerto Rican, Cuban, Central/South American, and Other Hispanic origin.

The 1995-1998 linked birth/infant death files include 437,870 plural births. Many previous studies of multiracial infants and numerous studies of infant mortality exclude plural births (Mangold and Powell-Griner 1991; Migone et al. 1991; Parker and Schoendorf 1992; Collins and David 1993; Hessol et al. 1998; Parker 2000). However, in order to retain the greatest number of multiple-race/ethnic births, this study includes plural births. The regression models incorporate a variable for plurality to account for these infants.

Sociodemographic Correlates of Race/Ethnicity and Infant Mortality Risk

The relationship between race/ethnicity and infant mortality is strongly related to sociodemographic factors and, specifically, socioeconomics status. Blacks and Mexican Americans, for example, are more likely than Whites to have less than a high school education, an annual family income below the poverty line, and to live in racially and ethnically segregated areas (Blank 2001; Massey 2001). These socioeconomic factors, in turn, are associated with low rates of prenatal care utilization (Echevarria and Frisbie 2001) and higher levels of infant mortality (Hummer 1993). While measures of family income, wealth, and residential segregation would be useful controls for socioeconomic status, they are unavailable in vital statistics data. Instead, we use maternal education as the sole socioeconomic indicator.

Socioeconomic status may also differentiate multi-racial/ethnic groups since previous studies cite higher levels of education as a correlate of race/ethnic intermarriage. Black women, for example, tend to marry more highly educated White men than White women do (Kalmijn 1993; Farley 1999; Fu 2001); a similar pattern has been exhibited among Mexican American women (Farley 1999; Fu 2001). In addition, Black men who marry White women tend to be more educated than Black men who marry Black women (Kalmijin 1993; Farley 1999; Fu 2001; Jacobs and Labov 2002). Therefore, it is not a coincidence that interracial Black-White families show a socioeconomic advantage over single race Black families (Parker and Lucas 2000; Farley 2002; Goldstein and Morning 2002; Wells 2003), which is likely to be associated with favorable pregnancy outcomes.

A number of studies of nativity and infant mortality reveal that foreign-born women are more likely to have positive pregnancy outcomes than native-born women, with explanations for this advantage including the positive selection of migration, the healthy lifestyles of immigrants, and data artifacts (Scribner 1996; Singh and Yu 1996; Frisbie et al. 1998; Hummer et al. 1999; Palloni and Morenoff 2001). Immigrant women are more likely to have healthy diets (Guendelman & Abrams 1995) and are less likely to smoke, to consume alcohol, or to use drugs than native-born women (Rumbaut & Weeks 1991; 1996). Thus, controlling for nativity in studies of race/ethnicity and infant mortality is critical. Maternal age is also an important correlate of infant mortality. Age has a curvilinear relationship with infant mortality, with a higher risk of death among teenage women and among older mothers (Singh and Yu 1995). The elevated risk of infant death among older women is thought to be a product of biological risks. On the other hand, teenage childbearing in the context of U.S. society is a response to social disadvantage (Geronimus 1987), with teenage mothers more likely to be poor, Black, and unmarried than older mothers. Therefore, maternal age serves as a crude proxy for social disadvantage in the absence of better controls for socioeconomic status. Along a similar vein, marital status is also an important indicator to include in this analysis due to the known higher risk of death associated with unmarried mothers. Infants of unmarried women are at higher risk for death largely due to inadequate familial resources rather than to marital status per se (Cramer 1987; Eberstein, Nam, and Hummer 1990).

Finally, infants born to high-parity[2] women may suffer from increased mortality risks due to not only the physical demands of frequent pregnancy and childbirth, but also due to time and resource demands of large families (Hummer et al 1995; Institute of Medicine 1985; Kleinman and Kessel 1987). High parity is more frequent among Black and Mexican American women and less frequent among White women (Matthews and Ventura 1997).

Proximate Determinants of Infant Mortality Risk

Birth outcomes—including prematurity, low birth weight, and very low birth weight—have been considered the strongest proximate determinants of infant mortality risk. Not only do adverse birth outcomes account for over 60% of infant deaths, but the distribution of birth outcomes also varies substantially by population subgroup. Infants born to Black mothers, for instance, are about twice as likely to weigh less than 2500 grams as those born to White mothers (Kochanek and Smith 2004). Teen mothers and mothers with low educational attainment also have elevated risks of low birth weight and as a consequence, infant mortality. We include simple measures of birth outcome to examine whether the observed infant mortality differentials operate entirely though elevated risks of these birth outcomes. These measures include gestational length (<37 weeks versus 37+ weeks) and birth weight (<1500 grams, 1500-2499 grams, and 2500+ grams).

We first provide a descriptive analysis that shows infant mortality differences across the 15 different combinations of maternal and paternal race/ethnicity. Then, before delineating the results to the additive statistical models, we first test statistical differences of groups in our study. We do this by testing the multiple linear hypotheses below using Model 1 (which only includes

[2] Parity is measured as recommended by Kleinman and Kessel (1987). High parity is defined as birth orders greater than one for women younger than 18 years of age, three or more live births to a mother between the ages of 18-25, and 4 or more live births after the age of 25.

race/ethnicity as covariates). The reported p-values come from the Wald chi-squared statistics testing three hypotheses:

$$H_0\text{: } \beta_S=\beta_{MRE}.$$

and

$$H_0\text{: } \beta_{MRE1}=\beta_{MRE2}$$

and

$$H_0\text{: } \beta_S=\beta_{Missing},\ H_0\text{: } \beta_S=\beta_{Other}$$

where *S* is a single-racial/ethnic group and *MRE* is a multi-racial/ethnic group. In the case of the first test, the multiracial group is one having the same maternal race/ethnic identifier as group *S* (for more on methods, see Allison 1999). For example, we test if Black-Whites are statistically different from single-race Blacks. The second tests whether the coefficients for multiracial groups having the same ancestral combination are equal (example: White-Black vs Black-White). The third test is similar to the first, but instead of testing equality with a multiracial group, it tests with groups that either have paternal race/ethnicity missing or have a paternal race/ethnicity other than White, Black, or Mexican American (or "Other"). For example, if infants having Black mothers with identifiable fathers are statistically different from those who race/ethnicity could not be ascertained. Regression models are then estimated that display the magnitude of the infant mortality differentials across the race/ethnic groups, while controlling for the sociodemographic correlates and proximate determinants identified previously. These models are estimated using binomial logistic regression, where the outcome of interest is infant death versus survival through the first year of life.

RESULTS

Table 1 displays the cross-tabulation of maternal by paternal race/ethnicity. Although previous studies of health outcomes emphasize interracial Black-White births, they are outnumbered by Mexican American-White interethnic births. The most common pairing of bi-race/ethnic infants is those whose mother is White and whose father is Mexican American, encompassing 1.9% of all births to White women. The second most common is births to White mothers and Black fathers, which accounts for 1.7% of births to White women. While numerically less plentiful than the above combinations, the combination of a Mexican American mothers and White fathers accounts for 7.3% of births to Mexican American women.

[Table 1 about here]

Unfortunately, bi-racial/ethnic births are identifiable only if both mother's *and* father's races/ethnicities are indicated on the birth certificate. While the vast majority of births to Mexican American (87.5%) and White (90.6%) mothers have paternal race/ethnicity present on the birth certificate, the same is not true for Black mothers: paternal race/ethnicity is missing for approximately 40% of cases. Mothers with missing paternal race/ethnicity are mostly unmarried (84%); almost all Black mothers who have missing paternal race/ethnic information (97%) are unmarried (not shown in table)[3].

Infant mortality rates (IMR)[4] for the 15 mother-father race/ethnic combinations are shown in Figure 1.[5] Single-race Black infants (i.e., "Black-Black" in the table) exhibit the second highest infant mortality rate of the 15 groups while single-ethnic Mexican Americans exhibit the lowest rate (11.6 and 5.2 deaths per 1000 live births, respectively). These findings are

[3] Detailed descriptive statistics are available from the authors upon request.
[4] The infant mortality rate is calculated by dividing the number of infant deaths by the number of live births.
[5] For example, "White-Black" refers to infants having a White mother and a Black father, whereas "White" refers to single-race White infants.

consistent with an abundance of studies on racial/ethnic differences in infant mortality rates. That is, in spite of their similar disadvantageous socioeconomic status with Blacks, Mexican Americans show an infant mortality rate lower than that of Whites.

[Figure 1 about here]

Most of the maternal-paternal racial/ethnic IMRs displayed in Figure 1 are similar to results from previous analyses of birth outcomes and infant mortality. That is, bi-racial Black-White and White-Black infants exhibit rates that are intermediate between their single-race Black and White counterparts. Conversely, Mexican American-White bi-ethnic infants (regardless if either the mother or father is White) exhibit elevated risks of infant mortality as compared to single-ethnic Mexican American and single-ethnic White infants, contrary to the results from Rogers' (1989) study. While infants born to White mothers and Mexican American fathers have an IMR of 6.5 and Mexican American-White infants have an IMR of 5.5, single-ethnic Whites and Mexican Americans exhibit rates even lower, at 5.3 and 5.2 respectively.

The most striking patterns in Figure 1 are the systematic, elevated mortality risks for infants of Black fathers and for infants with unknown paternal race/ethnicity. For pairings with identifiable parental race/ethnicity, infants with Black fathers show the highest within-maternal race/ethnic group IMRs. An interesting finding is the greatly elevated mortality risk for infants among whom father's race/ethnicity is unknown – a pattern exhibited for each of the three maternal race/ethnic categories. For example, infants born to White mothers and fathers with missing race/ethnicity have an IMR of 11.2 per 1000, far higher than any of the identifiable race/ethnic parental combinations among White women.

Table 2 displays results from chi-square tests to determine if the infant mortality risks of bi-racial/ethnic infants are statistically different from one another and from their single-race/ethnic counterparts. The three single-race/ethnic groups are listed at the top of the table; the 12 multi-race/ethnic groups are listed along the left side. Looking first at the far right column of the table, we see that Black-White and White-Black infants do not statistically differ in mortality risks; nor do Mexican American-Black infants and Black-Mexican American infants differ from one another. However, Mexican American-White and White-Mexican American odds of death do differ from one another. Looking at the interior of the table, one can see that White-Mexican American infants are distinct from both single-race Whites and single-ethnic Mexican Americans. However, the infant mortality risks of the reverse pairing (Mexican American-White) *are not* statistically different from either single-ethnic Whites or single-ethnic Mexican Americans.

In short, these preliminary findings begin to question the practice of using only maternal racial/ethnic identification in health research. These results provide two important insights. First, maternal identification may not be adequate for some groups. If we utilized standard techniques for categorizing White infants, for example, White-Mexican infants would be identified as single-ethnic White, when in fact, they are not only different from Mexicans, but they also statistically differ from White infants. Second, for other groups, it is possible to combine interracial infants with other groups either by their respective racial combinations or by the maternal racial/ethnic determinant (the standard). For instance, interracial Black-White and White-Black births, on the one hand, are similar to one another, but different from single-race Blacks and Whites. Irrespective of which parent is Black or White, they may be amalgamated into one group. On the other hand, Mexican-White infants do not statistically differ from Mexicans or Whites, hence the options to combine this group with others is more elastic. Therefore, researchers should exercise caution in handling racial data and avoid haphazardly combining racial/ethnic categories by conducting statistical tests for differences prior to aggregating groups.

[Table 2 about here]

Perhaps most important, births having missing paternal race/ethnicity appear to be distinct sub-groups compared to infants who have both maternal and paternal race/ethnicity reported. The IMRs displayed in Figure 1 showed that infants whose paternal race/ethnicity is unknown have a considerably elevated risk of death. The chi-square tests from Table 2 further show that they are statistically different from infants whose parents share the same race/ethnic background. Infants of Black, Mexican, and White mothers with missing paternal race/ethnicity have quite elevated risks of death compared to their single racial/ethnic counterparts. In short, for most of the tests considered here, infant mortality risks do vary by both maternal and paternal race/ethnicity.

To help determine what influences the race/ethnic differences reported above, we turn to Table 3, which exhibits risk factor percentage distributions by race/ethnicity of infant. White mothers with same-race partners exhibit the lowest sociodemographic risk profile across all of these racial/ethnic groups. Infants of White mothers and Black or Mexican American fathers have a more risky profile and share strikingly similar patterns. Compared to single-race White infants, both groups have higher, but similar, percentages of teenage mothers, high parity births, and mothers with less than a high school education. Marital status is the only distinguishing characteristic between the two groups. More than one-half (56.2%) of births to White mothers/Black fathers are to unmarried parents, whereas only 33.2% of births to White mothers/Mexican American fathers are non-marital.

Inter-racial/ethnic infants born to Black mothers are quite distinctive. Black mothers with White fathers are more likely to be foreign born, less likely to be unmarried, less likely to be teens, and more likely to have 13+ years of education than Black mothers having a same-race partner. Unlike White-Black couples, the majority of Black-White couples are married (63.5%). With the exception of infants born to Black-missing parents, Black-Mexican American infants have the highest percentage of teen and unmarried mothers (24.8% and 53.9%, respectively), the highest percentage with less than a high school education (24.8%), and the highest percentage of premature births (17.6%).

When looking at births to Mexican American mothers, single-ethnic Mexican and bi-ethnic Mexican American-Black infants tend to have similar risk factor profiles (excluding nativity), while Mexican American-Whites tend to have the most favorable within-group risk profile. For example, Mexican American-White infants have the lowest percentages of prematurity (11.9%) and mothers who are unmarried (22.1%), teenagers (10.2%), and who have less than a high school education (16.9%). On the other hand, Mexican American-Black infants are characterized by much higher percentages on these same risk factors. All in all, these descriptions show that infant risk profiles not only depend upon maternal race/ethnicity, but also upon paternal race/ethnicity.

Multivariate Models of Race/Ethnicity and Infant Mortality

Table 4 presents logistic regression findings reported in the form of odds ratios. Results from Model 1 produce a ranking of risk consistent with the infant mortality rates displayed previously. Note that the White-White combination is the reference group. When also considering nativity (Model 2), significant changes only occur among infants born to Mexican American women: controlling for nativity results in an increased risk of mortality for most of the

Mexican American groups in comparison to White/White infants. This change indicates that the relatively favorable survival exhibited by several of the Mexican American subgroups of infants is partially attributable to immigrant women – either because of positive immigrant selectivity, protective cultural factors, or loss of some infants to follow-up (e.g., if the birth occurred in the U.S. and the infant later died in Mexico) (Hummer et al. 1999; Palloni and Morenoff 2001).

Turning to Model 3, sociodemographic factors appear to account for a significant, but nowhere near complete, share of the variation in mortality risk across these groups. For infants with Black fathers, the reduction in risk ranging from 14% to 26%, with the largest change among single-race Blacks followed by White-Black births. Similarly, all infants having a Mexican father show a decline in risk from 10% to 23%, with sociodemographic characteristics explaining the greatest change for Black-Mexican American infants in comparison to the reference group of single-race White infants. These findings show that racial and ethnic differences across these sociodemographic characteristics partially account for the dissimilar infant mortality rates across these groups. While controlling for age, education, marital status, and parity explains a significant share of the elevated risk for a number of the groups, these controls explain relatively little for Black-White births. After adding sociodemographic factors, the odds of infant death as compared to single-race White infants decreases from 70% higher to 62% higher.

Model 4 adds the powerful predictors of birth weight, gestational age, and parity. Because birth weight and gestational age are so strongly linked to infant survival and differ across groups, it should be expected that controls for them eliminate most of the remaining race/ethnic differentials. And, clearly, this is the case. For example, the infant mortality difference between Black-White and single-race White births is completely eliminated in model

4. Nevertheless, a number of the groups continue to display disparities with single-race White women in the context of model 4, indicating that infant mortality differences across these groups are not solely due to differences in the birth weight and gestational age distributions of the groups. For example, White-Black, White-Mexican American, and Mexican American-Black births all exhibit higher odds of infant death than single-race after controlling for birth outcomes. Interestingly, all groups of women for whom father's race/ethnicity is missing also continue to exhibit elevated risks of infant mortality, even net of marital status, education, birth weight, gestational age, and more. Clearly, having a missing report of father's race/ethnicity on a birth certificate signifies something much more important than missing data.

CONCLUSION

Our results show that the race/ethnicity of both parents is important for infant mortality. Before introducing sociodemographic indicators and birth outcomes, no consistent mortality trend for mixed racial/ethnic births could be applied to all groups. In some instances multiracial infants tend to reside in-between their single-race equivalents; in others they are at polarized extremes or the highest-risk group. For example, birth to interracial White/Black and interethnic Mexican/Black unions exhibited death rates intermediate between their single racial/ethnic counterparts, while births to interethnic Mexican and White unions had the highest within-group risk. However, when considering maternal characteristics and pregnancy outcomes, all mixed racial/ethnic infants retaining statistical significance converge to a common trend. Namely, one that puts them at an elevated risk of death compared to their single-racial/ethnic equivalents.

Although differences in mortality are apparent, specifically identifying bi-racial/ethnic infants matters more for some mixed ancestry subgroups than others. Our chi-square tests comparing bi-racial/ethnic births to their singe race equivalents questions whether mixed racial/ethnic groups should be treated as a mutually exclusive group. With more studies emerging making use of data allowing multiple responses to race questions, no one has addressed whether mixed racial/ethnic populations are different from mono-racial/ethnic groups in the risk of infant death. Yet our findings suggest that only a few groups are statistically different. White-Mexican and interracial combinations of White-Black births differ from their single racial/ethnic equivalents. However, Mexican-Whites do not differ from Mexicans or Whites while combinations of interethnic Mexican-Blacks do not differ from mono-racial Blacks. Since these observations may not be consistent for all outcomes, we recommend testing for equality of effects for all analyses when dealing with mixed racial/ethnic groups.

One unexpected finding occurred among infants having missing paternal race/ethnicity on the birth certificate. Taken as a collective group, they have the highest risk for death among almost all racial/ethnic groups. One explanation may be that missing father's information may indicate lack of paternal involvement during the mother's pregnancy. The most pertinent contribution of fathers to positive pregnancy outcomes is the provision of socioeconomic resources. In addition, since the majority of these women are unmarried, they face the additional financial burden and responsibilities involved in being the head of the household. Tests for equality effects also find that groups having missing paternal race are statistically different from those having one present. This provides further evidence for our suspicion that these mothers live in a more disadvantaged economic situation than those whose paternal information is present on the birth certificate.

Hence, systematic differences by race of mother and father exist. Non-randomness of intermarriage and the unique socioeconomic climate of multiracial households may explain why bi-racial/ethnic infants differ from their single racial/ethnic counterparts in birth outcomes. In addition, previous analyses of interracial household also find that mixed-racial households fare better socioeconomically than single-race Black, but not single race White households, which may account for these patterns.

Health surveillance systems and NCHS reports currently use one-race/ethnic designations. Our study has one important implication to this practice overall, especially in addressing racial/ethnic disparities. Observed improvements in the health of racial/ethnic minorities over time may be a result of compositional effects or, as Rogers (1989) puts it, an artifact of how race/ethnicity is coded. Many multi-racial/ethnic groups are socioeconomically advantaged compared to their minority counterparts, which may explain their relatively favorable health outcomes. Therefore, the relative improvements in rates, such as infant mortality, over time may be an artifact of the way mixed-race categories are combined with single-race designations, rather than absolute improvements in health for racial/ethnic minorities as a result of policy changes. In the short run, this may not affect estimates from states such as Maine or Vermont, where intermarriage is uncommon, however it certainly affects states such California, New York, Texas, and Hawaii where mixed-racial/ethnic births are on the rise. In the long run, say by 2050, national estimates of infant mortality rates may also become sensitive to how race and ethnicity are coded, since multiracials are expected to encompass 21% of the U.S. population by that time. The authors suggest researchers take appropriate steps, such as statistical tests for differences, before amalgamating mixed-racial/ethnic groups.

How to analyze data for persons of mixed-race ancestry points to a broader issue of including paternal characteristics in health surveys, and even including them as risk factors for birth outcomes. Much of the prior research centers on the idea that maternal characteristics take center stage in infant mortality, and paternal characteristics are seldom considered. If fathers did not bring anything to the table, then this practice would not be questioned. However, our analysis finds that birth outcomes do vary by race/ethnicity of mother and the father. Indeed, fathers bring some element to the infant health equation that is unquestionably beyond their racial/ethnic attributes. By including more detailed information on vital statistics and health surveys on fathers—such as paternal education—policies aimed at improving infant health could be better structured, particularly those targeted toward racial/ethnic minorities.

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Table 1: Cross-Classification of Births by Race/Ethnicity of Mother and Race/Ethnicity of Father, U.S., 1995-1998

	Paternal Race/Ethnicity					
Maternal Race/Ethnicity	White	Black	Mexican	Other	Missing	Total
White %	85.0	1.7	1.9	1.9	9.4	100.0
# of Births	8,191,992	168,303	186,946	182,408	903,353	9,633,002
Black %	1.8	56.9	0.3	0.8	40.2	100.0
# of Births	41,323	1,342,678	7,933	19,608	947,118	2,358,660
Mexican American %	7.3	1.3	75.1	3.8	12.5	100.0
# of Births	145,289	25,168	1,490,631	76,239	247,221	1,984,548
Total	8,378,604	1,536,149	1,685,510	278,255	2,097,692	13,976,210

Note: "White" refers to non-Hispanic White, "Black" refers to non-Hispanic Black, and "Mexican American" refers to Hispanic Mexican American

Figure 1: Infant Mortality Rates by Race/Ethnicity of Parents

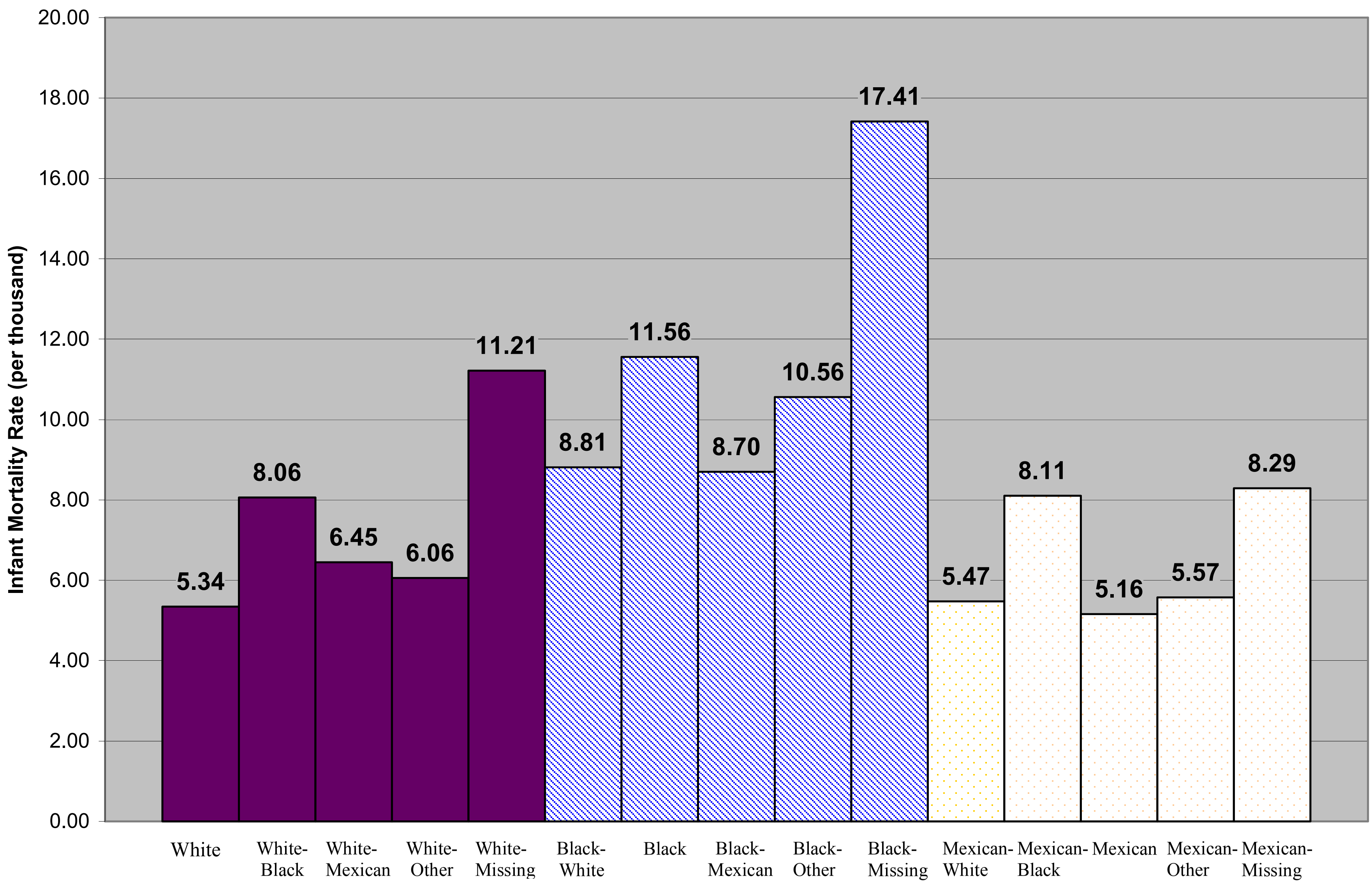

Table 2: Test for Equality of Effects

	Single Racial/Ethnic Groups			
Multi-racial/ethnic Groups	**White**	**Black**	**Mexican**	Same Group*
Black-White	*	*	---------	0.13
White-Black	*	*	---------	
Mexican-White	0.5		0.12	*
White-Mexican	*	---------	*	
Black-Mexican	---------	*	*	0.61
Mexican-Black	---------	0.09	*	
White-Other	*	---------	---------	
Mexican-Other	---------	---------	0.12	
Black-Other	---------	0.19	---------	
White-Missing	*	---------	---------	*
Mexican-Missing	---------	---------	*	
Black-Missing	---------	*	---------	

* Same group tests include: Black-White=White-Black, White-Mexican=Mexican-White, Black-Mexican=Mexican-Black, and White-Missing=Mexican-Missing=Black-Missing
* $p < 0.05$

Table 3: Infant Mortality Risk Factor Percentage Distributions by Race/Ethnicity of Parents, U.S., 1995-1998

Maternal Race/Ethnicity	Non-Hispanic White					Non-Hispanic Black					Hispanic Mexican American				
Paternal Race/Ethnicity*	White	Black	Mexican	Other	Missing	White	Black	Mexican	Other	Missing	White	Black	Mexican	Other	Missing
Place of Birth															
US	94.9	95.0	95.6	94.5	95.8	86.2	88.0	95.2	87.9	94.8	78.4	84.0	32.2	43.5	48.3
Foreign	5.1	5.0	4.4	5.5	4.2	13.8	12.0	4.8	12.1	5.2	21.6	16.0	67.8	56.5	51.7
Maternal Age															
10-19	6.7	18.7	18.0	13.3	30.8	13.0	15.4	24.8	18.5	33.1	10.2	20.0	16.3	17.0	32.9
20-34	78.3	73.0	73.1	73.9	62.3	73.9	73.6	69.0	71.4	61.3	77.4	74.5	76.0	74.7	62.4
35+	15.0	8.3	8.9	12.8	7.0	13.2	11.0	6.2	10.1	5.6	12.5	5.5	7.7	8.3	4.7
Marital Status															
Unmarried	13.1	56.2	33.2	29.3	88.4	36.5	51.5	53.9	54.0	97.2	22.1	55.2	30.6	38.9	94.5
Married	86.9	43.8	66.8	70.7	11.7	63.5	48.5	46.1	46.0	2.8	77.9	44.8	69.5	61.1	5.5
Mother's Education															
<12 Years	9.9	21.7	23.6	16.6	37.2	13.6	18.6	24.8	20.2	41.5	16.9	27.3	60.4	44.2	66.7
12 Years	32.1	41.2	39.0	35.6	40.1	34.8	39.1	40.4	35.9	40.1	37.4	43.2	26.7	33.3	24.8
13+ Years	58.0	37.1	37.5	47.8	22.7	51.7	42.3	34.8	43.9	18.4	45.7	29.5	13.0	22.5	8.5
Parity															
First Birth	40.5	45.2	41.3	43.8	55.5	43.5	36.6	42.1	42.6	41.7	41.2	40.2	34.3	41.3	49.3
Low Parity	48.8	39.5	42.4	43.6	30.8	41.9	42.9	37.1	39.6	31.3	46.4	39.8	43.3	41.8	29.6
High Parity	10.7	15.3	16.3	12.6	13.7	14.7	20.5	20.8	17.9	27.0	12.5	20.0	22.4	16.9	21.1
Birth weight															
<1500 grams	1.1	1.5	1.2	1.2	2.0	2.3	2.9	2.5	2.8	3.6	1.1	1.4	1.0	1.1	1.3
1500-2499 grams	5.0	6.0	5.4	5.4	7.6	7.8	9.2	8.4	8.6	11.5	4.6	5.6	4.7	4.9	6.3
≥ 2500 grams	93.9	92.5	93.4	93.4	90.3	89.9	87.9	89.0	88.7	85.0	94.3	93.1	94.4	94.0	92.4
Gestational Age															
≥ 37 weeks	90.1	88.3	88.1	89.2	86.2	85.1	83.1	82.5	84.1	79.4	88.1	85.7	87.5	86.7	85.2
< 37 weeks	9.9	11.8	11.9	10.8	13.8	14.9	16.9	17.6	15.9	20.6	11.9	14.3	12.5	13.3	14.8
Plural Births															
Yes	3.2	2.6	2.4	2.7	2.4	3.4	3.1	3.6	3.1	2.9	2.3	2.2	1.8	1.9	1.8
No	96.9	97.5	97.6	97.3	97.6	96.6	96.9	96.5	96.9	97.1	97.7	97.8	98.2	98.1	98.2

Source: NCHS Linked Birth and Infant Death Files, 1995-1998
Columns may not total to 100% due to rounding
*"White" refers to non-Hispanic White, "Black" refers to non-Hispanic Black, and "Mexican" refers to Hispanic Mexican American
Mexican Americans are identified by "Hispanic, Mexican American" with no regard to racial background

Table 4: Adjusted Odds Ratios for the Effects of Risk Factors on Infant Mortality, U.S., 1995-1998

	Model 1	Model 2	Model 3	Model 4
Race/Ethnicity: Mother-Father				
White-Black	1.51**	1.52**	1.36**	1.20**
White-Mexican	1.21**	1.22**	1.12*	1.06*
White-Other	1.14**	1.14**	1.07*	1.05
White-Missing	2.11**	1.98**	1.55**	1.31**
Black-White	1.66**	1.70**	1.62**	1.05
Black-Black	2.18**	2.21**	1.95**	1.10**
Black-Mexican	1.63**	1.65**	1.42*	0.87
Black-Other	1.99**	2.02**	1.73**	1.02
Black-Missing	3.30**	3.17**	2.34**	1.28**
Mexican-White	1.02	1.07	1.02	1.01
Mexican-Black	1.52**	1.52**	1.38**	1.25*
Mexican-Mexican	0.97*	1.12**	0.94**	0.93**
Mexican-Other	1.04	1.18*	1.04	0.98
Mexican-Missing	1.56**	1.68**	1.22**	1.17**
Nativity				
Foreign Born		0.79**	0.80**	0.88**
Maternal Age				
< 19			1.12**	1.18**
35+			1.11**	0.89**
Marital Status				
Unmarried			1.19**	1.06**
Maternal Education				
< 12 years			1.21**	1.16**
Parity				
First Birth			0.99	0.86**
High			1.37**	1.25**
Birth weight				
< 1500 grams				72.03**
1500-2499 grams				4.54**
Gestational Age				
< 37 weeks				1.79**
Plurality				
> 1				0.78**
-2 Log L	1302386	1276777	1226824.3	902659.2
Df	15	16	22	26

** p< 0.0001
* p< 0.01