CROSS-STATE DIFFERENCES IN THE PROCESSES GENERATING BLACK-WHITE DISPARITIES IN NEONATAL MORTALITY

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ABSTRACT

The neonatal mortality rate for black infants is twice that of white infants. To better understand this dramatic disparity, the black-white gap in neonatal mortality can be decomposed based on two generating-mechanisms: 1) disparities due to racial differences in the distribution of birth weights, and 2) those due to differences in birth weight-specific mortality. In this paper, I utilize this distinction to explore how the social context into which infants are born contributes to gaps in neonatal mortality between blacks and whites. Drawing on linked infant birth and death records from 1995-2002, I first provide evidence that the magnitude of the black-white gap in neonatal mortality varies across 38 states. For each state, I then calculate the relative contribution of differences in birth weight distribution versus differences in birth weight-specific mortality to disparities in neonatal mortality between whites and blacks. After controlling for key individual-level characteristics, two general patterns emerge. In some states, the black-white gap in neonatal mortality is entirely a product of differences in health at birth. In other states, differential receipt of medical care contributes to disparities in very low birth weight mortality between white and black neonates. This has important implications for efforts to understand the persistence of racial disparities in neonatal mortality.

CROSS-STATE DIFFERENCES IN THE PROCESSES GENERATING BLACK-WHITE DISPARITIES IN NEONATAL MORTALITY

Despite reductions in infant mortality rates over the past 50 years, black infants have twice the likelihood of mortality as white infants (Collins and David 2009; Singh and Yu 1995). This disparity is also observed in the neonatal period, the critical first 27 days of an infant's life in which two thirds of infant deaths take place. In 2013, the neonatal mortality rate for black infants was 7.46 per 1,000 live births compared to a rate of 3.34 per 1,000 for white infants (Mathews et al. 2015). This provides a powerful example of the disparate life chances facing white and black Americans.

Scholars have dedicated considerable effort to understanding differences in neonatal mortality between black and white infants. Evidence supports a number of explanations for this phenomenon including racial differences in: socioeconomic resources (Braveman et al. 2014), receipt of prenatal and hospital care (Vintzileos et al. 2002a; Howell et al. 2008), exposure to discrimination and other stressors (Hogue and Bremmer 2005), and exposure to contextual risk factors (O'Campo et al. 2008; Pearl et al. 2001). These explanations can be grouped into two broad categories: (1) differences between white and black mothers that result in differences in infant health at birth, and (2) differences that result in differential rates of mortality, conditional on health at birth (Elder et al. 2011). To distinguish the relative contribution of these two kinds of explanations, racial inequalities in neonatal mortality can be decomposed into two corresponding components: those due to differences in the distribution of birth weights between whites and blacks and those due to differences in birth weight-specific mortality (Gortmaker and Wise 1997).

Research that decomposes racial disparities in neonatal mortality in this way has made important contributions to our understanding of infant health gaps between blacks and whites

(e.g. Elder et al. 2011; Carmichael and Ilyasu 1998; Schempf et al. 2007). However, scholars have yet to take full advantage of this approach. A key benefit of distinguishing between disparities that are due to differences in birth weight distributions and disparities due to birth weight-specific mortality is that each component can be linked to different types of social factors (Wise 2003). Specifically, differences in the distribution of birth weight between groups are linked to factors that affect mothers before conception or during pregnancy. In contrast, differences in mortality among very low birth weight neonates are due to differential receipt of appropriate medical care at birth. As a result, exploring racial differences in birth weight distribution and birth weight-specific mortality can shed light on how social context contributes to gaps in neonatal mortality between blacks and whites.

In the U.S., states are sites of key variation in infant mortality. Not only do infant mortality rates and racial disparities in infant mortality vary dramatically across states (Brown Speights et al. 2017; Mathews et al. 2015), but medical systems and other factors that matter for infant health are organized at the state-level (Elder et al. 2014). Further, recent research highlights differences in socioeconomic inequalities in infant mortality across states (Sosnaud 2019). In this paper, I explore variation in black/white inequality in neonatal mortality across 38 states. For each state, I calculate the relative contribution of racial differences in birth weight distribution versus racial differences in birth weight-specific mortality to disparities in neonatal mortality between whites and blacks. Based on this distinction, I identify two groups of states: states in which the black-white gap in neonatal mortality is entirely a product of differences in health at birth, and states in which differential receipt of medical care contributes to disparities in mortality between very low birth weight white and black neonates.

BACKGROUND

Neonatal mortality refers to death in a newborn's first 28 days of life. Deaths during this period are typically rooted in factors relating to pregnancy and childbirth (Gortmaker and Wise 1997). The primary causes of neonatal mortality include prematurity and low birth weight, congenital malformations, and pregnancy complications (Anderson and Smith 2005). These represent most of the leading causes of infant mortality, and more than two-thirds of all infant deaths occur during the neonatal period.[1]

In the past half-century, rates of neonatal mortality in the United States declined from 17.7 deaths per 1,000 live births in 1965, to 4.04 deaths per 1,000 in 2013 (Eisner et al. 1978; Mathews et al. 2015). However, this dramatic improvement has not resulted in a reduction in disparities in the risk of neonatal mortality between blacks and whites—in 2013, the neonatal mortality rate for black infants was 7.46 per 1,000 live births compared to a rate of 3.34 per 1,000 for white infants (Mathews et al. 2015). Thus, black mothers experience more than 4 additional neonatal deaths for every 1,000 live births and black neonates have 2.2 times the mortality rate of whites.

Research on disparities in neonatal mortality between blacks and whites has focused on a range of possible explanations.[2] These include racial differences in socioeconomic resources and receipt of medical care (Braveman et al. 2014; Collins et al. 1997; Vintzileos et al. 2002a; Howell et al. 2008), exposure to discrimination and other stressors (Hogue and Bremmer 2005), and exposure to neighborhood-level risk factors (Collins et al. 2009; O'Campo et al. 2008; Pearl

[1] In contrast, common causes of deaths during the post neonatal period (28 days to 1 year) include Sudden Infant Death Syndrome, congenital malformations, accidents and injuries, and infections (Anderson and Smith 2005).
[2] Evidence does not support the proposition that racial disparities in infant mortality are due to genetic differences in maternal or infant health between blacks and whites (David and Collins 2007).

et al. 2001). These explanations can be organized based on two general mechanisms which produce differences in neonatal mortality between blacks and whites: (1) differences between white and black mothers that result in differences in infant health at birth, and (2) differences that result in differential rates of mortality, conditional on health at birth.

Racial differences in health at birth

Health at birth is typically measured by birth weight and gestational age. Not only are low birth weight and preterm birth leading causes of neonatal mortality, but they also increase the risk of other causes of infant mortality like respiratory distress and congenital malformations (Callaghan et al. 2006; Eberstein et al. 1990; MacDorman 2011). The presence of racial inequalities in birth weight and gestational age has been well-established (Alexander et al. 2003; Collins and David 2009; Lu and Halfon 2003). Although research on this issue has been unable to conclusively explain racial differences in health at birth, evidence suggests that several key factors are likely to play an important role.

First, there is some evidence that an infant's health at birth is influenced by maternal receipt of prenatal care (Vintzileos et al. 2002a; 2002b; cf Fiscella 1995). In addition to screening fetuses for potential health issues, prenatal care provides mothers with information about nutrition and other practices that promote maternal and fetal health. There are notable disparities in the quality and use of prenatal care between black and white mothers (Alexander et al. 2002; Collins et al. 1997; Kogan et al. 1994; Mayberry et al. 2000). While some of these care disparities can been traced to socioeconomic factors, there is strong evidence that racial disparities in medical care persist even among patients with similar levels of socioeconomic resources (Barfield et al., 1996; Smedley et al., 2003). These differences in have been linked to

biases and stereotypes held by medical providers as well as perceived discrimination and mistrust by black patients (Balsa and McGuire 2003; LaVeist et al. 2000).

A rich literature explores the relationship between maternal stress and infant health at birth. When individuals feel stress, they experience an increase in stress hormones. Chronic exposure to these hormones can cause a number of health problems (McEwen 1998), and emerging evidence suggests that the health consequences of stress extend to a fetus (Wadhwa et al. 2011). A number of scholars have explored the hypothesis that differential exposure to stressors helps to explain differences in birth weight and gestational age between blacks and whites (Collins and David 2009; Kramer and Hogue 2009; Lu and Halfon 2003). This research highlights racism and racial discrimination as chronic stressors that can increase the risk of prematurity and low birth weight among black mothers (Collins et al. 2004; Hogue and Bremmer 2005; Mustillo et al. 2004).

Another line of research traces racial disparities in infant health at birth to neighborhood-level factors. Due to segregation and the legacy of residential discrimination, blacks and whites experience differential rates of exposure to concentrated poverty and neighborhood disadvantage (Logan 2013; Massey and Denton 1993). Research has repeatedly shown an association between residence in low-income neighborhoods and low birth weight and premature birth, even after accounting for a mother's personal socioeconomic resources (Collins et al. 2009; O'Campo et al. 2008). Further, some evidence suggests that the effects of neighborhood quality on infant health may be especially pronounced among black mothers (Pearl et al. 2001). Scholars are working to better understand the pathways through which disadvantaged neighborhoods affect infant health at birth, and possible explanations include the availability of services, exposure to environmental toxins, and the effects of segregation (Williams 1999). Overall, the accumulation of evidence

supports the notion that neighborhood-level factors contribute to racial disparities in the risk of being born prematurely and with low birth weight.

Racial differences in neonatal mortality, conditional on health at birth

Even after accounting for the increased prevalence of high-risk births among black mothers, black and white infants experience different rates of in neonatal mortality. In 2008, black infants of normal birth weight (2500g or more) were 1.26 times more likely to experience neonatal mortality than white infants of comparable weight. Black infants of very low birth weight (less than 1500g) were 1.14 times more likely to experience neonatal mortality as whites of comparable weight. In contrast, black infants of low birth weight (1500-2499g) were slightly less likely to experience neonatal mortality than low birth weight white infants. Similar patterns are observed for differences in mortality conditional on gestational age (Matthews and MacDorman 2012).

A leading explanation for racial disparities in mortality among neonates born with similar health status is that there are differences in the receipt of medical care between black and whites newborns. Evidence indicates that these differences can take many forms. For example, black neonates may be disadvantaged is accessing specific medical interventions. Hamvas and colleagues (1996) examine differences in mortality between very low birth weight black and white neonates following expansion of the use of surfactant therapy to treat respiratory distress syndrome after 1990. They find that racial inequalities actually increased after this treatment was introduced because of greater reductions in mortality among white neonates. This suggests that there was differential receipt of surfactant therapy between black and white newborns (see also Frisbie et al. 2004).

There is also evidence that racial disparities in neonatal mortality reflect differences in the quality of hospitals where black and white infants are born. Racial segregation persists as a problem for many hospitals (Smith 1998), and Howell and colleagues (2008) show that very low birth weight white infants in New York were more likely than black infants to be born in the hospitals with the best record of preventing neonatal mortality. They estimate that if black mothers delivered in the same hospitals as white mothers, disparities in neonatal mortality among very low birth weight infants between blacks and whites would be reduced by 34.5% (see also Morales et al. 2005).

Finally, even when black and white infants have access to the same medical facilities, there may be racial disparities in the quality of care received. Recent evidence from an analysis of California Neonatal Intensive Care Units (NICUs) suggests that while black-white differences in quality of care provided to infants are relatively small in low-performing NICUs, as NICU performance improves, there are substantial racial disparities in quality of care (Profit et al. 2017). This finding is consistent with the growing recognition that race influences how mothers and infants are treated by health practitioners during and after birth (Declercq et al. 2013; Matoba 2017). More research is needed on this topic, but differences in the quality of care provided by practitioners stands out as another way that medical treatment can contribute to the persistence of disparities in mortality among black and white neonates with similar health risks.

Birth weight distribution and birth weight-specific mortality

Together, differences in infant health at birth and differences in mortality conditional on health status at birth combine to produce the observed disparities in neonatal mortality between black and whites. In order to calculate the relative contribution of each of these factors, inequalities in neonatal mortality can be stratified into two corresponding components:

inequalities due to differences in the distribution of birth weights and those due to differences in birth weight-specific mortality (Gortmaker and Wise 1997).[3] For example, Vital Statistics records from 1995-2002 show that black infants are 1.9 times more likely to be born with low birth weight (LBW) and 2.7 times more likely to be born with very low birth weight (VLBW) than white infants (see Table 1). This *difference in the distribution of birth weights* indicates that black infants are more likely to be born at high risk of neonatal mortality than white infants. Further, among those who are born with very low birth weight, black infants face a likelihood of neonatal mortality that is 1.1 times greater than white infants (Mathews and MacDorman 2012). This represents a *difference in birth weight-specific mortality*. Based on this information, it is possible to calculate the extent to which each factor contributes to disparities in neonatal mortality using a demographic decomposition technique (Carmichael and Iyasu 1998; Kitagawa 1955).

Scholars have long utilized this approach, and this work has produced several notable findings. For one, the decline in neonatal mortality in recent decades has been driven largely by improvements in birth weight-specific mortality (Gortmaker and Wise 1997). Buehler and colleagues (1987) analyze reductions in neonatal mortality observed between 1960 and 1980. They find that 84% of the reduction for white infants was due to lower birth weight-specific mortality and 16% was due to a healthier distribution of birth weights. For black infants, all of the reduction in neonatal mortality during this period was due to improved birth weight-specific

[3] I focus on birth weight as the key indicator of infant health at birth in order to maximize consistency with previous research (e.g. Carmichael and Iyasu 1998; Gortmaker and Wise 1997; Wise 2003) and because of the difficulty in obtaining accurate measures of gestational age using vital statistics data (David and Collins 2007; Dietz et al. 2007; Kramer and Hogue 2009).

mortality (the distribution of black birth weights actually became slightly less favorable over this period).

While reductions in neonatal mortality over time were predominantly driven by trends in mortality at given birth weight categories, racial disparities in neonatal mortality are primarily due to differences in the distribution of birth weights between blacks and whites. Carmichael and Iyasu (1998) examine data from 1983 and 1991 and show that as much as 90% of racial disparities in infant mortality and 100% of racial disparities in neonatal mortality are due to differences in the distribution of birth weights between blacks and whites. This is consistent with estimates from more recent periods (Elder et al. 2011), and with estimates that use gestational age as an alternative measure of health at birth (Schempf et al. 2007). Compared to whites, black infants are approximately three times as likely to be born with very low birth weight and almost twice as likely to be born with low birth weight (Mathews and MacDorman 2012).

Since the factors that contribute to health at birth are different from the factors that explain neonatal mortality conditional on health at birth, a key benefit of decomposing racial inequalities in neonatal mortality is that each component can be linked to different types of contextual factors (Wise 2003). As previously discussed, differences in the distribution of birth weights are due to factors that affect mothers before conception and during pregnancy like use and quality of prenatal care, exposure to stressors like discrimination and racism, and exposure to disadvantaged neighborhoods (Collins and David 2009). In contrast, disparities in neonatal mortality, especially among infants born at very low weight, can be linked to differential receipt of medical treatments like obstetrical interventions and neonatal intensive care technology (Hamvas et al. 1996; Wise 2003). Thus, in populations where the birth weight distribution explains an especially high proportion of the racial disparity in neonatal mortality, there may be

something about the social setting which increases the likelihood that black infants will be born with a high risk of neonatal mortality. However, in populations where differences in very low birth weight mortality play a more prominent role in explaining racial disparities in neonatal mortality, it suggests that blacks are disadvantaged in obtaining obstetrical and post-birth medical care compared to whites (Howell, 2008).

Variation in inequality across contexts

Prior research emphasizes that the distinction between differences in birth weight distributions and differences in birth weight-specific mortality can inform research on the role of social context in producing racial inequalities in neonatal mortality. However, despite the potential benefits, scholars using this approach have paid little attention to variation in the relative importance of birth weight distribution and birth weight specific mortality across populations. An exception is Buehler and colleagues (1987) who examine differences in the extent to which reductions in infant mortality can be explained by improvements in birth weight-specific mortality across four U.S. regions. They find that patterns are similar for blacks and whites in the Northeast but differ in other regions. This provides evidence that the factors that contribute to racial disparities in infant mortality are not the same in all contexts.

More recent analyses of birth weight distribution and birth weight-specific mortality identify states as potentially important sites of variation. In their analysis of the relative importance of birth weight distribution and birth weight-specific mortality to black-white disparities in infant mortality, Elder and colleagues (2011) mention employment, social services, pollution, and health care as key state-level factors that might contribute to inequalities in infant mortality between blacks and whites (see also Elder et al. 2014). Elder and colleagues capture the effect of such state-level factors with indicator variables for each state. However, this

approach does not examine the extent to which the relative contribution of differences in birth weight distribution and differences in birth weight-specific mortality to disparities in infant mortality varies across states.

In this paper, I explore cross-state variation in racial inequality in neonatal mortality. I first provide evidence of variation in the gap in neonatal mortality across 38 states for which adequate data are available. For each state, I then calculate the relative contribution of racial differences in birth weight distribution versus differences in birth weight-specific mortality to disparities in neonatal mortality between whites and blacks. Based on this distinction, I identify two groups of states: states in which racial disparities in neonatal mortality are entirely a product of differences in health at birth (measured with birth weight), and states in which differential receipt of medical care contributes to disparities in very low birth weight mortality between whites and blacks.

DATA AND METHODS

This project uses infant birth and death records compiled by the National Vital Statistics System (NVSS). The NVSS links birth and death certificates for all infants born in the United States (National Center for Health Statistics 2001-2006).[4] I utilize records from births occurring in 1995-2002.[5] In all, this consists of 31,120,898 individual birth records. The linked data files include information on an infant's birth and age at death. I measure neonatal mortality with a dichotomous variable indicating whether the infant died in the first 27 days of life.

[4] The NVSS is able to successfully link almost 99% of all infant deaths to corresponding birth certificates. For example, in 2002, only 292 out of 27,527 infant deaths were unlinked.

[5] In 2003, the birth certificate form was revised and several key variables (including maternal education) are considered incompatible with the previous versions (Mathews and MacDorman 2012).

The linked birth-death records include information on a number of additional individual-level characteristics. I use data on mother's race/ethnicity to create dummy variables for births to non-Hispanic white and non-Hispanic black mothers. I measure infant's sex with a dummy variable for male infants. Mother's age is measured with dummy variables for six age groups <20, 20-24, 25-29 (reference category), 30-34, 35-39, and 40+. Birth history is measured with dummy variables for 1st birth, 2nd birth (reference category), 3rd birth, 4th birth, and 5th or greater birth. The measure of maternal education captures four categories of educational attainment: less than 12 years of schooling, 12 years of schooling, less than 4 years of college, and 4 years of college or more. I employ dummy variables for each education category (with less than 12 years of schooling serving as the reference category).

Control variables were chosen based on two criteria. First, prior research identifies these factors as key predictors of birth weight and infant mortality (Mathews et al. 2004; Mathews and MacDorman 2012). If the distribution of these characteristics between blacks and whites varies across states, then geographic patterning of racial inequalities in neonatal mortality could reflect differences in demographic composition. Controlling for key predictors of neonatal mortality shows the extent to which disparities vary when comparing mothers and infants with similar mortality risk. Second, I include only characteristics that are determined before mothers receive any information on the health of the fetus. This ensures that infant's health status does not influence any of the control variables. For example, I do not control for prenatal care because mothers who learn that their infants are at risk may seek out and receive additional prenatal care. If so, then including prenatal care measures could result in a negative association between prenatal care and neonatal mortality (Elder et al. 2011).

The analysis proceeds in three stages. I first evaluate the extent to which racial inequalities in neonatal mortality vary across states after accounting for differences in socio-demographic composition. I measure this pattern with a series of logistic regression models predicting neonatal mortality in 38 states (in 12 of the 50 states, the low number of births to black mothers does not permit an analysis of neonatal mortality[6]). I estimate separate models for infants of white and black mothers, and each model includes controls for maternal age, infant's sex, maternal birth history, and maternal education. In addition, I restrict the analysis to non-plural births. The models pool data from 1995-2002 and include year fixed-effects to account for time trends in each state. Based on these analyses, I calculate the predicted probability of neonatal mortality for white and black mothers in each state. I then calculate racial inequalities in neonatal mortality as the difference in these respective probabilities. When calculating predicted probabilities, I set the values of control variables as second born daughters of mothers ages 25-29 with 4 years of college or more. Infants with these characteristics are the least likely to experience mortality (Mathews et al. 2004).

In the second stage of the analysis, I calculate the proportion of the disparity that is due to racial differences in birth weight distribution and the proportion of the disparity that is due to racial differences in birth weight-specific mortality. The first step in this calculation is to decompose the disparity in neonatal mortality between blacks and whites into two components using the following formulas (Carmichael and Iyasu 1998; Kitagawa 1955):

Component 1: Disparities due to differences in birth weight distribution

$$[(R_{bi} + R_{wi}) / 2] \times (P_{bi} - P_{wi})$$

[6] These 12 states are AK, HI ID, ME, MT, NH, NM, ND, SD, UT, VT, WY

Component 2: Disparities due to differences in birth weight-specific mortality

$$[(P_{bi} + P_{wi}) / 2] \times (R_{bi} - R_{wi})$$

R_{bi} and R_{wi} are the neonatal mortality rates for black and white infants in each of (i) birth weight categories (VLBW, LBW, and NBW). P_{bi} and P_{wi} are the proportions of black and white infants in each birth weight category (i). Summing across all three birth weight categories gives the total disparity in neonatal mortality between whites and blacks for each component. These totals can then be divided by the black-white difference in neonatal mortality to produce the proportion of the disparity due to each component. Using the NVSS linked infant birth-death data, I calculate this proportion for the U.S. as a whole and separately for 38 states. Given the important role of births to very low birth weight infants in predicting neonatal mortality, I also calculate the proportion of the total black-white gap in neonatal mortality due to racial differences in the likelihood of being born with *very low birth weight* and the proportion due to differential mortality between black and white infants in this high risk category.

In the third stage of the analysis, I replicate the calculations from the previous stage after adjusting for the key control variables discussed above. I implement this adjustment with state and race-specific regression models predicting the distribution of birth weight and birth weight-specific mortality for non-plural, second born daughters of mothers ages 25-29 with 4 years of college or more.[7] When predicting the distribution of birth weights, I treat birth weight as a three-category ordinal variable with categories for very low birth weight, low birth weight, and normal birth weight. For 31 states,[8] I estimate ordinal logistic regression models of birth weight

[7] Regression results are not shown, but are available by request from the author.

[8] In 7 states (DE, IA, MN, NE, OR, RI, WV) the data are insufficient to produce estimates in models that include controls for individual-level characteristics.

on the socio-demographic control variables that (models also include year fixed-effects). Based on these models, I predict the probability that black and white infants will be born in one of the three birth weight categories, given the values of the control variables. To model birth weight-specific mortality, I run separate logistic regression models of neonatal mortality on the socio-demographic controls (plus year fixed effects) for VLBW, LBW, and NBW infants. I use the results of these models to predict the probability of neonatal mortality for black and white infants at each birth weight category. Based on these two sets of predicted probabilities, I calculate the proportion of the disparity that is due to racial differences in birth weight distribution and the proportion of the disparity that is due to racial differences in birth weight-specific mortality using the decomposition formula discussed in above.

RESULTS

Racial inequalities in neonatal mortality across states

Figure 1 maps differences in neonatal mortality between blacks and whites for each state.[9] The analysis controls for key socio-demographic factors, including mother's education. Consistent with previous research (Schoendorf et al. 1992), this figure shows that racial gaps in mortality are present even among the offspring of highly educated mothers. Further, the figure shows that although inequalities in neonatal mortality are present in all states, the magnitude of these differences varies substantially across states. Several notable trends are apparent. Gaps in neonatal mortality tend to be smaller in the Northeast and larger in Southern states. However,

[9] The correlation between the black neonatal mortality rate and the white neonatal mortality rate across states is .595 before controlling for socio-demographic composition and .554 after controlling for socio-demographic composition.

several states in the Midwest including Wisconsin, Illinois, and Michigan also have large inequalities in the risk of neonatal mortality between blacks and whites. The analysis controls for a number of key individual-level socio-demographic factors relevant to infant health. Thus, the observed variation suggests that there may be contextual factors that operate at the state level which influence the relationship between race and neonatal morality.

[FIGURE 1 ABOUT HERE]

Decomposing racial disparities in neonatal mortality

Table 1 presents the decomposition of black-white disparities in neonatal mortality for the United States as a whole. The first three columns display information on white births and the next three columns display information on black births. As shown in the first column, 1.14% of white infants are born with very low birth weight and 5.44% are born with low birth weight. In contrast, black infants are 2.7 times as likely to be born with very low birth weight (3.13%) and 1.9 times as likely to be born with low birth weight (10.09%) (Column 4). This supports the widely established finding that the distribution of birth weight among black infants put them at higher risk of mortality (Mathews and MacDorman 2012). Comparing whites and blacks in columns 2 and 5 shows that rates of neonatal mortality among VLBW and NBW white infants are lower than for black infants at comparable birth weights. However, black infants in the low birth weight category are actually less likely to experience neonatal mortality than white LBW infants. This supports research showing a black survival advantage for infants in this category (Alexander et al. 2003; Iyasu et al. 1992; Matthews and MacDorman 2012). Taken together, this reflects the two mechanisms that lead to disparities in neonatal mortality between blacks and whites: 1) differences in health at birth (reflected in the greater concentration of black infants in the high risk VLBW and LBW categories), and 2) differences in mortality, conditional on health

at birth (reflected in higher black rates of infant mortality in two of the three birth weight categories).

In order to understand the relative contribution of these mechanisms to inequalities in neonatal mortality between blacks and whites, I decompose racial disparities in neonatal mortality into two corresponding components: 1) disparities due to differences in birth weight distribution and 2) disparities due to differences in birth weight-specific mortality. Overall, the neonatal mortality rate is 3.759 deaths per 1,000 live births for whites and 8.981 deaths per 1,000 for blacks. This means that the total gap in neonatal mortality between black and white infants is 5.222 deaths per 1,000 live births. Of these extra 5.222 black neonatal deaths, the decomposition analysis shows that 4.711 are due to differences in the distribution of birth weights between whites and blacks and .512 are due to differences in birth weight specific mortality. Thus, roughly 90% of the disparity in neonatal mortality between blacks and whites is due to racial differences in birth weight distribution (4.711/5.222) and the remaining 10% is due to differences in birth weight specific mortality (.512/5.222). These estimates are comparable in magnitude to previous research (Elder et al. 2011; Carmichael and Ilyasu 1998; Schempf et al. 2007).

[TABLE 1 ABOUT HERE]

This analysis confirms that at the national-level, black-white disparities in neonatal mortality are driven predominantly driven by racial differences in the distribution of birth weights. However, as shown in Figure 1, there is substantial variation in the magnitude of the black-white gap in neonatal mortality across states. This suggests that the processes generating racial disparities in neonatal mortality may also vary across states. To evaluate this proposition, I conduct separate decompositions of the black-white gap in neonatal mortality for 38 states. Table

2 presents the results of this analysis. Column 1 displays the proportion of the black-white gap in neonatal mortality due to racial differences in the distribution of birth weights and Column 2 displays and the proportion due to racial differences in birth weight-specific mortality. In many states, the role of birth weight-specific mortality is comparable to the national average of approximately 10%. For example, in Alabama, California, Florida, and Kansas, between 8-10% of the black-white gap in neonatal morality is due to racial differences in mortality among infants of similar birth weight. The proportion is notably higher than the national average in other states. In Colorado, Iowa, South Carolina, and Tennessee, different rates of birth weight-specific mortality explain more than 20% of the disparity in neonatal mortality between blacks and whites. Finally, in a handful of states (Arkansas, Kentucky, Louisiana, Oklahoma, Oregon, and Texas), differences in birth weight-specific mortality account for a negative proportion of the black-white disparity in neonatal mortality. This means that in these states, blacks are actually advantaged compared to whites in birth weight-specific mortality and that gaps in mortality would be bigger if black infants had the same neonatal mortality rates as whites, conditional on birth weight.

In Columns 3 and 4 of Table 2, I focus specifically on the contribution of very low birth weight infants to racial disparities in neonatal mortality. I calculate the percentage of each state's total black-white gap in neonatal mortality due to racial differences in the risk of being born with very low birth weight and the percentage due to differences in mortality among very low birth weight neonates.[10] The results are largely similar to Columns 1 and 2, emphasizing the extent to which very low birth weight infants drive disparities in neonatal mortality between blacks and

[10] Unlike Columns 1 and 2, Columns 3 and 4 do not sum to 100%. The remaining proportion is the percentage of the black-white gap due racial differences stemming from low birth weight and normal birth weight births.

whites. In addition, the results in Column 4 show that there is cross-state variation in the contribution of differential mortality among very low birth weight infants to the black-white gap in neonatal mortality. This analysis of differential mortality among very low birth weight neonates is useful because it is the clearest way to identify disparities that can be traced to differences in the receipt of post-birth medical care (Wise 2003).

[TABLE 2 ABOUT HERE]

Figure 2 displays a map of the information found in Columns 4 of Table 2. The map reveals some evidence of geographic patterning in the extent to which very low birth weight-specific mortality contributes to disparities in neonatal mortality between blacks and whites. For example, the states in which a high proportion of the disparity is due to racial differences in very low birth weight mortality are largely found in the South and the Midwest. In addition, four of the eight states where differences in birth weight-specific mortality make a negative contribution to black-white disparities in neonatal mortality, are clustered from the Texas Panhandle to the Mississippi River. This type of geographic patterning is consistent with the hypothesis that state-level factors help to explain cross-state variation in the relative contribution of birth weight distribution and birth weight-specific mortality to racial disparities in neonatal mortality. However, it is also possible that state-level differences simply reflect the characteristics of individuals who comprise state populations. In order to help isolate the effects of state context, I estimate the proportion of the total black-white disparity in neonatal mortality due to racial differences in very low birth weight-specific mortality after adjusting for key individual-level predictors of birth weight and neonatal mortality. These include mother's age, educational attainment, birth history, and infant's sex and plurality.

[FIGURE 2 ABOUT HERE]

Figure 3 maps the results of this analysis for 31 states in which the analysis can be conducted. When comparing births with similar characteristics (second born daughters of mothers ages 25-29 with 4 years of college or more), several patterns stand out. For one, the number of states where differential mortality among very low birth weight infants explains a negative proportion of the total black-white gap in neonatal mortality increases. Very low birth weight black infants have an advantage in 12 of the 31 states. However, in the 19 other states, excess mortality among very low birth weight black infants continues to make a contribution to racial disparities in neonatal mortality. This contribution is most pronounced in Southern states, as well as Arizona, California, and Colorado. This suggests that even among those with similar characteristics, high risk white neonates are advantaged in receiving critical medical care compared to black neonates in these states (Wise 2003). In contrast, in states where the contribution of differences in very low birth weight-specific mortality is small (or negative), the black-white disparity in neonatal mortality is largely (or entirely) due to racial differences in the distribution of birth weight.

[FIGURE 3 ABOUT HERE]

DISCUSSION

This paper explores disparities in the risk of neonatal mortality between black and white infants in 38 U.S. states. I first present evidence that while gaps are present in all states, the magnitude of the disparity in mortality varies considerably across states. This analysis controls for key individual-level predictors of neonatal mortality. I find that population demographics are not sufficient to explain cross-state variation, highlighting the possibility that state context influences the relationship between race and neonatal mortality. This is consistent with research on the social factors that contribute to variation in inequality across populations (Beckfield and

Kreiger 2009; Sosnaud 2019). To better understand the mechanisms producing disparities in neonatal mortality between blacks and whites, I decompose these disparities into two components 1) disparities due to racial differences in birth weight distribution, and 2) disparities due to racial differences in birth weight-specific mortality. At the national-level, racial differences in birth weight-specific mortality explain only 10% of the black-white gap in neonatal mortality, but this proportion varies substantially across states.

Initial analyses that do not account for individual-level characteristics show that the proportion of the racial disparity explained by differences in mortality among very low birth weight neonates ranges from a high of 26% to a low of -45%. After controlling for individual-level predictors of birth weight and neonatal mortality, two general patterns emerge. In some states (including Arizona, California, and Colorado), racial differences in mortality between very low birth weight infants make a substantial contribution to the black-white gap in neonatal mortality. However, in other states (including Oklahoma, Nevada, and Texas), very low birth weight-specific mortality explains a negative proportion of inequality in neonatal mortality. This means that in these areas, the black-white gap in neonatal mortality is entirely due to differences in birth weight distribution between blacks and whites.

The presence of cross-state variation in the relative contribution of birth weight distribution and birth weight-specific mortality to black-white disparities in neonatal mortality has a number of important implications. Since differences in mortality between very low birth weight neonates can be traced to differential receipt of obstetrical interventions and medical technology (Wise 2003), the high proportion of the disparity due to this component in states like Colorado and Mississippi indicates that, in these states, high risk black and white neonates do not receive the same medical care during this critical period. The fact that this pattern is observed

among infants of mothers with 4 years of college or more suggests that such inequalities in medical care are observed even for those from similar socioeconomic backgrounds. Thus, a key issue for future research is to better understand the factors that contribute to racial disparities in newborn care (Bryant et al. 2010). One possibility is that black mothers do not receive the same quality of hospital care as whites due to racial bias by providers (Council of Ethical and Judicial Affairs 1990; Matoba 2017; Williams 1999) or the continued racial segregation of hospitals (Howell et al 2008; Smith 1998). However, cross-state variation in the importance of very low birth weight-specific mortality (even among states within the same geographic region) highlights the complexity of this issue.

In some states, very low birth weight-specific mortality explains a negative proportion of racial disparities. This indicates that in these areas, black infants actually have advantages over whites in obtaining neonatal intensive care and other vital post-birth technologies (Wise 2003; see also Schwartz et al. 2000). While further analysis is required to pinpoint the source of these advantages, one hypothesis revolves around the geographic distribution of black and white populations within states. Neonatal intensive care units are more prevalent in large, high-volume hospitals, and it is not uncommon for most hospitals in major cities to offer neonatal intensive care services. This means that this critical technology will be available to the majority of infants born in urban areas (Wise et al. 1985; 1988). In contrast, in rural areas served by smaller hospitals, the availability of neonatal intensive care is not guaranteed and mothers must travel long distances to hospitals with NICUs in order to receive potentially lifesaving care (Bishop-Royse and Eberstein 2013; Gortmaker and Wise 1997). If black infants are more likely to be born in urban areas than white infants in some states, then the observed advantage in very low birth weight-specific mortality in these states could be due to greater availability of neonatal

intensive care (Schwartz et al. 2000). Thus, a promising direction for future research is to explore the relationship between birth in urban areas, NICU availability, and racial inequalities in neonatal mortality.

It is important to note that even in states where there is evidence that blacks are advantaged in newborn care, racial disparities in neonatal mortality are still observed. For example, in Illinois, -3% of the gap in neonatal mortality between blacks and whites with similar characteristics is due to very low birth weight-specific mortality, but black mothers still experience an additional 3.62 neonatal deaths per 1,000 live births than white mothers. This means that in these states, stark racial differences in the distribution of birth weights produce the observed disparities in the risk of neonatal mortality. This pattern continues even when comparing mothers with 4 years of college or more, supporting the notion that racial differences in birth weight are not simply a product of socioeconomic inequalities between blacks and whites (Lu and Halfon 2003). Moreover, a key finding from this analysis is that the importance of racial differences in the distribution of birth weights is not the same in all states. While much of the existing literature on this issue focuses on individual-level predictors of infant health at birth like exposure to stress and discrimination (e.g. Collins et al. 2004), this project calls attention to the role of state-context in shaping black-white disparities in health at birth. Thus, an important avenue for future research is to identify the state-level institutions, processes that increase or reduce racial differences in the risk of giving birth to infants with a high risk of neonatal mortality (LaVeist 1993; Polednak 1991).

Although the analysis presented here has important implications for the study of the black-white gap in neonatal mortality, it is also subject to some notable limitations. For one, birth weight is an imperfect measure of an infant's health at birth (Wilcox 2001). While being born at

low or very low birth weight is highly correlated with neonatal mortality, gestational age is a more proximate predictor of health at birth (Kramer and Hogue 2008). However, the measurement of gestational age in Vital Statistics data is considered unreliable, with biases especially likely to be observed when analyzing socio-demographic differences (Dietz et al. 2007). As a result, I follow previous research seeking to compose racial disparities in neonatal mortality and rely on birth weight as a measure of infant health at birth (e.g. Carmichael and Iyasu 1998; Elder et al. 2011).

Another limitation concerns the ability to adjust for individual-level characteristics. While the linked birth/death records used in this analysis contain information on a valuable set of socio-demographic factors, there are other key predictors of neonatal mortality that cannot be effectively controlled. For example, it would be helpful to account for differences in family income and health insurance coverage when comparing black and white neonates from similar socioeconomic backgrounds, but this information is not collected in national Vital Statistics records. This highlights the value of future research that focuses directly on the inequalities observed in a given state and collects more information on a more detailed set of individual-level characteristics.

Finally, the results presented here do not cover all 50 states. Even though the data are essentially the population of births and deaths for an eight year period, there were only enough observations of black infants to reliably predict neonatal mortality in 38 states (and only 31 states in analyses adjusting for control variables). For example, from 1995-2002 there were only 791 births and 7 neonatal deaths among black mothers in Maine. Moreover, there were 33 neonatal deaths among black mothers in Oregon, and only 3 of these deaths were among college-educated

mothers. This population size is insufficient to predict neonatal mortality after adjusting for this control variable.

The persistence of racial disparities in the likelihood of neonatal mortality serves as a powerful example of the disparate life chances facing whites and black Americans. Research has established that the black-white gap in infant mortality cannot be explained by a single factor and is likely to be the product of a number of interacting processes that are reinforced within and across generations (Collins and Daivd; Lu and Halfon 2003). The results presented here emphasize that these processes do not play out in the same way in all populations and call attention to the potential for state social context to contribute to disparities in infant mortality between blacks and whites.

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Table 1: Contribution of birth weight distribution and birth weight-specific mortality to racial differences in neonatal mortality, United States 1995-2002

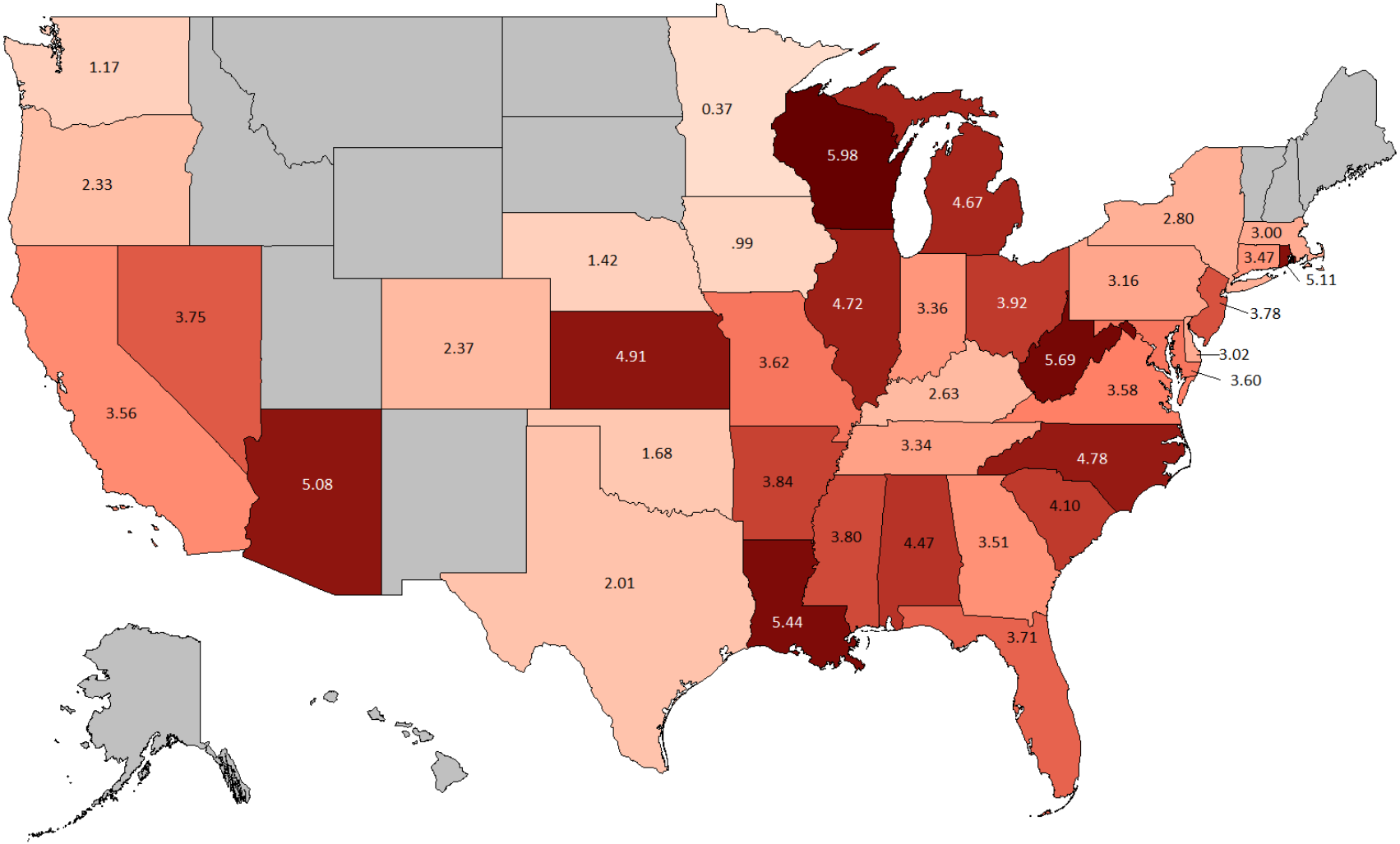
	White births			Black births			B-W difference in neonatal mortality		
Birth weight category	BW distribution %	BW-specific mortality rate (per 1,000)	Neonatal deaths (per 1,000)	BW distribution %	BW-specific mortality rate (per 1,000)	Neonatal deaths (per 1,000)	Black-White Difference	BW distribution	BW-specific mortality
VLBW	1.14	209.266	2.386	3.13	230.884	7.227	4.841	4.379	0.462
LBW	5.44	9.697	0.528	10.09	7.482	0.755	0.227	0.399	-0.172
NBW	93.42	0.905	0.845	86.78	1.152	.999	0.154	-0.068	0.222
Total	100%		**3.759**	100%		**8.981**	**5.222**	4.711	0.512

Note: "BW" is used as an abbreviation of "Birth Weight"

Table 2: Decomposition of black-white disparities in neonatal mortality by state, 1995-2002

State	**Column 1** % of black-white gap due to BW distribution	**Column 2** % of black-white gap due to BW-specific mortality	**Column 3** % of black-white gap due to differences in VLBW births	**Column 4** % of black-white gap due to VLBW-specific mortality
AL	91.56	8.44	85.62	10.74
AZ	96.66	3.34	87.44	3.07
AR	107.05	-7.05	95.96	-3.53
CA	91.36	8.64	84.24	6.46
CO	71.55	28.45	67.97	25.76
CT	97.04	2.96	92.56	6.22
DE	87.96	12.04	82.42	15.96
FL	91.60	8.40	85.98	6.91
GA	85.69	14.31	79.24	12.31
IL	89.34	10.66	81.96	5.98
IN	94.74	5.26	87.13	9.12
IA	75.39	24.61	70.82	12.12
KS	90.91	9.09	83.31	11.66
KY	114.22	-14.22	105.41	-12.98
LA	111.97	-11.97	103.33	-4.95
MD	88.21	11.79	84.05	10.23
MA	87.04	12.96	83.51	10.65
MI	85.53	14.47	79.92	13.66
MN	87.88	12.12	80.73	-1.30
MS	81.58	18.42	73.14	17.60
MO	81.98	18.02	75.70	14.31
NE	80.87	19.13	74.11	19.48
NV	86.05	13.95	76.66	-8.44
NJ	83.75	16.25	79.59	9.01
NY	88.39	11.61	83.70	6.51
NC	88.07	11.93	83.20	12.86
OH	92.61	7.39	85.95	7.76
OK	112.36	-12.36	101.34	-6.49
OR	191.45	-91.45	162.33	-45.47
PA	93.72	6.28	87.27	4.75
RI	86.82	13.18	81.07	8.80
SC	77.73	22.27	71.85	18.53
TN	77.53	22.47	72.27	19.68
TX	113.06	-13.06	104.00	-7.02
VA	82.22	17.78	77.01	15.30
WA	86.31	13.69	79.82	14.70
WV	86.78	13.22	80.28	15.21
WI	83.44	16.56	76.35	12.68

Figure 1: Difference in neonatal mortality rate (deaths per 1,000 live births) – black vs. white neonates, 1995-2002 (includes controls)



Differences for non-plural, second born daughters of mothers age 25-29 with 4 years of college or more. Darker shades represent larger differences between black and white neonates.

Figure 2: Percentage of total black-white disparity in neonatal mortality explained by racial differences in very low birth weight-specific mortality, 1995-2002

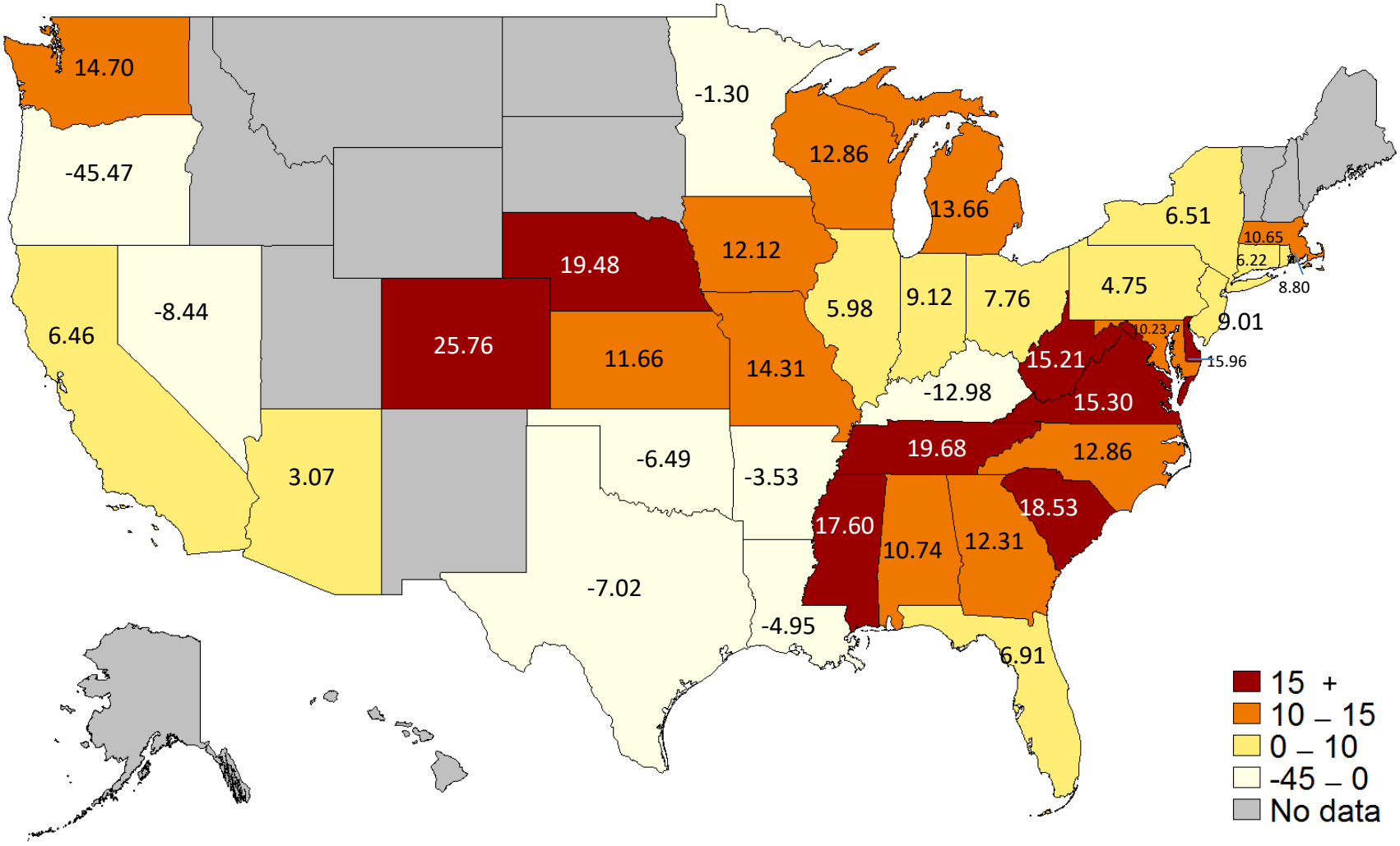
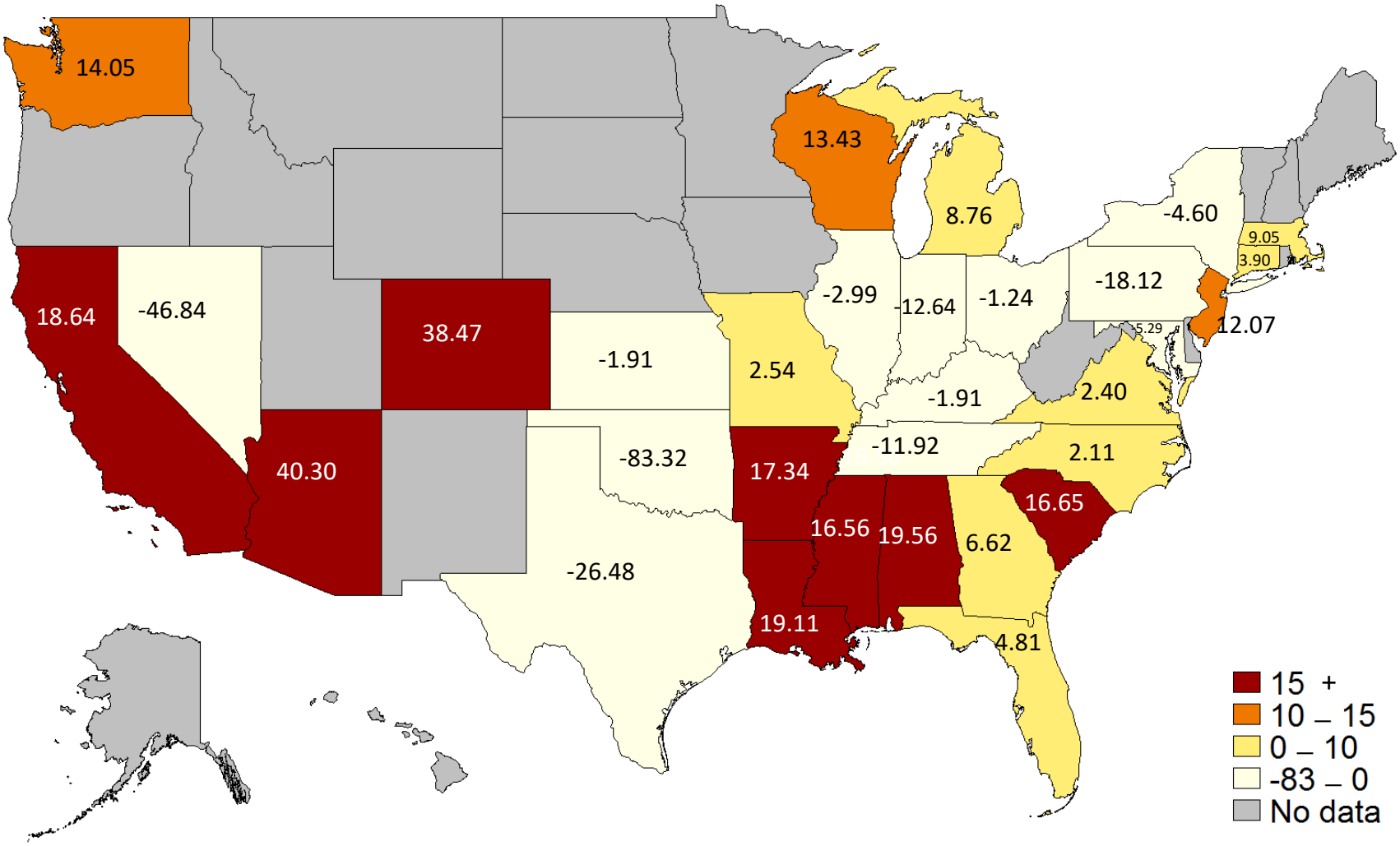


Figure 3: Percentage of total black-white disparity in neonatal mortality explained by racial differences in very low birth weight-specific mortality (including control variables), 1995-2002



Proportions for non-plural, second born daughters of mothers age 25-29 with 4 years of college or more.