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Racialized Patterns Of Inequality In United States Birth Outcomes, 1990-2018

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Abstract

Low birthweight is a pernicious public health problem that has seen little to no improvement in the United States for over 50 years. Being born low birth weight carries an increased risk of a broad range of adverse health and development outcomes and has been identified as a likely mechanism through which health and socioeconomic inequality is reproduced across generations. Racial disparities in birth weight are particularly stark. However, despite considerable attention to the issue, existing research fails to fully explain the social, institutional, and historical processes that operate to uphold racialized inequality in adverse birth outcomes. In light of recent declines in average birth weight and increases in pre-term births over recent decades, this puzzle is of particular importance to the public health and medical community, as well as to the racially minoritized populations affected by these shifts. The current dissertation approaches the problem from three different angles to better understand how racialized patterns in birth weight inequality are shaped via 1) vast shifts in the timing and level of participation in the institutions of marriage and education over time and the associated implications for racialized age patterns of low birth weight risk; 2) rapid increases in the use of obstetric interventions that have had widespread implications for the distribution of births by gestational age; and 3) the dilution of Black voting power via racialized disenfranchisement. Using standard regression techniques, classic demographic life table methods, and decomposition techniques, this dissertation finds that racialized disparities in educational attainment, exposure to obstetric intervention, and political exclusion all operate to exacerbate and/or maintain long-standing disparities in birth weight risk for racially minoritized populations. Implications of this work for future research and policy call for increased attention to the institutional and historical processes that produce racialized patterns of risk for adverse birth outcomes in Black communities.

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ABSTRACT

RACIALIZED PATTERNS OF INEQUALITY IN UNITED STATES BIRTH OUTCOMES, 1990 – 2018

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Low birthweight is a pernicious public health problem that has seen little to no improvement in the United States for over 50 years. Being born low birth weight carries an increased risk of a broad range of adverse health and development outcomes and has been identified as a likely mechanism through which health and socioeconomic inequality is reproduced across generations. Racial disparities in birth weight are particularly stark. However, despite considerable attention to the issue, existing research fails to fully explain the social, institutional, and historical processes that operate to uphold racialized inequality in adverse birth outcomes. In light of recent declines in average birth weight and increases in pre-term births over recent decades, this puzzle is of particular importance to the public health and medical community, as well as to the racially minoritized populations affected by these shifts. The current dissertation approaches the problem from three different angles to better understand how racialized patterns in birth weight inequality are shaped via 1) vast shifts in the timing and level of participation in the institutions of marriage and education over time and the associated implications for racialized age patterns of low birth weight risk; 2) rapid increases in the use of obstetric interventions that have had widespread implications for the distribution of births by gestational age; and 3) the dilution of Black voting power via racialized disenfranchisement.

Using standard regression techniques, classic demographic life table methods, and decomposition techniques, this dissertation finds that racialized disparities in educational attainment, exposure to obstetric intervention, and political exclusion all operate to exacerbate and/or maintain long-standing disparities in birth weight risk for racially minoritized populations. Implications of this work for future research and policy call for increased attention to the institutional and historical processes that produce racialized patterns of risk for adverse birth outcomes in Black communities.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Background

Infants born weighing less than 2500 grams (or 5 pounds 8 ounces) experience a higher risk of mortality and higher rates of morbidity across nearly all the body's organ systems (Institute of Medicine 2006; Pallotto and Kilbride 2006; Paneth 1995). Respiratory disorders, intestinal complications, immune deficiencies, cardiovascular disorders, hearing and vision problems, and neurological dysfunction all occur at much higher rates in infants born low birth weight (Institute of Medicine 2006). Over the life course, being born low birth weight is also associated with increased risk of learning disabilities, lower educational attainment, and adult chronic medical conditions, such as diabetes, hypertension, and heart disease (Goldenberg and Culhane 2007; Paneth 1995).

Despite receiving considerable attention from researchers and policy makers, low birth weight has remained an enduring public health problem in the United States. According to the Centers for Disease Control and Prevention (CDC) National Vital Statistics Report (NVSS), in 2016, over 8% of babies born in the United States weighed less than 2500 grams at birth, a number that has seen little to no change since the middle of the 20th century (Martin et al. 2018). Among 32 OECD countries, the United States ranks 28th in low birth weight. In the world, the United States ranks 67th, falling behind several lower income countries (Rothwell 2015).

Early research on birth weight focused on establishing a set of risk and protective factors, usually assessed during pregnancy, that were found to be associated with adverse birth outcomes (Blumenshine et al. 2010). Such studies typically included individual health-related behaviors (e.g., prenatal smoking or adequacy and timing of antenatal care), social support (e.g., marital status at the time of birth), and prenatal SES, among others. More recent studies have begun to hone in on the pre-conception period, employing a life course approach that acknowledges pre-conception and prenatal health as a reflection of a one's exposures prior to pregnancy (e.g., childhood SES, stressful life events, and/or lifelong neighborhood exposures) (Collins et al. 2004; Strutz, Richardson, and Hussey 2014).

Despite a growing understanding that birth outcomes, as with individual health trajectories, are a product of one's experiences across time and space (Ben-Shlomo and Kuh 2002; Kuh et al. 2003) , efforts to reduce pre-term birth and low birth weight have focused primarily on improving the adequacy of prenatal care rather than addressing the larger social and structural underpinnings of pre-conception and prenatal health. However, while a vast expansion in Medicaid eligibility enacted by the US Congress in the late 1980s cut the percentage of pregnant people who were not receiving prenatal care in half over the proceeding decade, this expansion of care did not ultimately translate to improvements in the rates of low birth weight and pre-term birth (Lantos and Lauderdale 2011).

Throughout the 1990s and 2000s, mean birth weight in the United States has declined and the incidence of low birth weight and pre-term birth has risen (Martin et al. 2018). Despite receiving considerable attention from both researchers and policymakers, the drivers of this upward trend in low birth weight and pre-term birth are not fully understood. Previous investigations have explored the role of distributional changes in gestational age, obstetric practices, and individual characteristics and behavior, with mixed results (Catov et al. 2016; Lantos and Lauderdale 2011; MacDorman, Declercq, and Zhang 2010).

While low birth weight remains a broad public health concern, the burden of risk for low birth weight and other adverse birth outcomes in the United States falls disproportionately on unmarried, poor, and Black birthing people (Blumenshine et al. 2010). Racial disparities in US birth outcomes are particularly stark, with non-Hispanic Black babies being nearly twice as likely to be born low birth weight as non-Hispanic White babies (Martin et al. 2018). Risk factors for low birth weight, such as high levels of stress exposure prior to pregnancy and nonmarital childbearing, are also socially patterned, with lower SES and Black people being at greater risk of exposure to these risk factors than higher SES and White people across the life course (Blumenshine et al. 2010). Given the social patterning of risk factors for low birth weight and the higher life-time risk of poor health and development outcomes for low birth weight infants, researchers have identified low birth weight as a key mechanism through which health and socioeconomic inequality may be reproduced across generations (Case, Lubotsky, and Paxson 2002; Currie 2009; Currie and Moretti 2007; Palloni 2006). However, despite the identification of low birth weight as a likely driver of intergenerational health inequalities, questions about the full range of factors that contribute to adverse birth outcomes, as well as the mechanisms through which they reproduce and evolve, remain largely unanswered.

Placing Racism at the Center of Racial Health Disparities Research

A large body of research has exposed a broad range of stark and seemingly intractable racial disparities in health and well-being in the United States, including low birth weight (Forde et al. 2019; Landrine et al. 2017; Link and Phelan 1995; Mehra, Boyd, and Ickovics 2017; Schaaf et al. 2012). However, while the inclusion of race in public health research studies is ubiquitous, its inclusion in statistical models is often done uncritically and without sufficient theoretical grounding. A recent scoping review of 650 systematically identified studies that sought to explain racial disparities in health found that only 21 (3%) of these studies explicitly used theory to conceptualize race and/or ethnicity and even fewer used theory to explain the social and structural relationships that uphold the racial hierarchy and produce disparate outcomes by race (Mannor and Malcoe 2022).

Racial inequity in measures of health, wealth, educational attainment, and incarceration are laid plain through descriptive statistics that describe the magnitude of these problems. However, too often and far too recently, social statisticians have drawn spurious conclusions that place race on the causal pathway for adverse outcomes rather than critically examining the broader social factors that confound the relationship between race and the outcome of interest (Edwin J. C. G. van den Oord and Rowe 2000; Roberts 2001).

While the racial-genetic model, which assumes a biological basis for observed racial differences, has largely been rejected by consensus among social and biological scientists, it is important to understand the historical underpinnings of this theory in order to reject its influence on modern scientific research. In his book *Thicker Than Blood: How Racial Statistics Lie*, Tukufu Zuberi gives a detailed account of how racial slavery and colonialism marked the evolution of racial stratification as a means of explaining human difference. Following emancipation in the Americas, racial stratification evolved to reinforce the existing power structure among free men and to justify the persistent inequality between racial groups (Zuberi 2001).

Racial stratification evolved and achieved scientific legitimacy as it drew upon Darwinian theories of evolutionary biology, thus forming the basis of the eugenics movement, which gave rise to racial statistics and the statistical methodologies still used by social scientists today (Zuberi 2001:4). However, there is now an abundance of genetic research indicating that there is in fact more genetic variation within individuals from the same racial groups than between racial groups. Furthermore, while racial classification systems are often meant to identify geographic and ancestral origin, a large Stanford study found that only 7% of alleles were specific to one geographical region and those alleles occurred in only 1% of the people from that region (Rosenberg et al. 2002). Thus, skin color, while genetically determined, is no more appropriate as an indicator of biological difference than the color of one's eyes or hair. Any investigation of racial disparities that fails to ground both the inquiry and the results of that investigation in a theoretical framework which implicates systemic racism as the fundamental causes of racial health disparities contributes, perhaps unwittingly, to a permissive discourse on racial essentialism.

Link and Phelan's (2015) theory of fundamental causes articulates how racism drives racial health inequalities through the restriction or promotion of access to "flexible resources" (Phelan and Link 2015). These flexible resources range from a) unequal representation in positions of power (e.g., within government, law enforcement, medical, or financial institutions) to b) individual resources of money, knowledge, power, and prestige that are disproportionately held by whites or c) the social psychological advantages inherently provided by living in a society predicated on white supremacy (Phelan and Link 2015).

This dissertation takes a social constructivist view of race, which rejects the notion that race is an individual-level biological characteristic. Rather, race is understood as an organizing system within which individuals construct their lives.

Throughout this dissertation, race is assumed to encompass the opportunities, advantages, and resources that are shaped by one's ascribed racial status and disparate outcomes by race are assumed to emerge from relational discriminatory processes at the individual, community, and institutional level. I will use demographic and statistical methods along with critical theory to examine long-standing racial inequity in rates of low birth weight and fill key gaps in our understanding of trends in birth weight and gestational age distributions in the United States. I will pay particular attention to how material disadvantage and structural racism operate on birth weight through maternal health over the life course.

Aims

Through the lens of the weathering hypothesis, the first chapter will explore how racialized patterns in both the distribution and association of educational attainment and marriage participation with low birth weight have evolved over time and contributed to racialized age patterns of risk for low birth weight. The second chapter will turn to the medical establishment and investigate the role of growing obstetric intervention rates in shaping racialized patterns of gestational length for Black vs. White births over time. Finally, the third chapter will investigate how the disproportionate disenfranchisement of Black voters through state-level criminal legal systems is associated with low birth weight for Black vs. White births.

Revisiting the Weathering Hypothesis

The first chapter will take a long-term look at the relationship between maternal race, age, and birth weight over the last 30 years to document the extent to which racialized weathering may be lessening, worsening, or stagnating over time. The weathering hypothesis, motivated by the observation that chronic health problems such as hypertension tended to occur at earlier ages within Black compared to White populations in the United States (Geronimus 1992), provides a means for understanding how social position, which structures stress exposure and material resources, may lead to a more rapid accumulation of risk over the life course for the health of racially minoritized groups. In the decades since the formation of the weathering hypothesis, three key population-level shifts warrant a re-evaluation of the phenomenon's relationship with birth weight over time.

First, the average age at first birth has increased over time, which, under the weathering hypothesis, has direct implications for racial disparities in birth outcomes. Relatedly, there has been a rapid expansion of educational attainment, particularly for women, in recent decades. While disparities in educational attainment remain substantial, since 1990, the percentage of both White and Black women earning a college degree by their mid 20s has doubled and tripled, respectively (US Census Bureau). Higher education has long been identified as a critical conduit for opportunity and advancement for young adults. College graduates are more likely to remain gainfully employed, avoid poverty, live longer, and remain healthier in old age (Garcia et al. 2021; Hout 2012). At the same time, the benefits of education have not been equally distributed across groups, both due to differential distribution of educational opportunities and because of differential health and socioeconomic returns to education between groups (Boen 2016; Bowles and Gintis 1976; Farmer and Ferraro 2005; Turner, Thomas, and Brown 2016). The first chapter of this dissertation will delve into the potential consequences of educational expansion for racial gaps in low birth weight and the racialized age patterns of risk for low birth weight over time.

Simultaneously with the expansion of educational attainment, non-marital childbearing rates have reached an all-time high in recent years, with marked racial variation in marital status at first birth (National Center for Health Statistics)(Curtin 2020). Similar to the diminished returns to education for Black populations, both the distribution and the protective value of marriage varies substantially by race (Roxburgh 2014; Willson 2003), suggesting that shifting patterns of non-marital childbearing may have different implications for Black vs. White births over time. Thus, the first chapter of this dissertation investigates the role of racial variation in both the distribution of non-marital childbearing and the association between marital status and birth weight on racialized age patterns of low birth weight over time.

Taken together, these demographic shifts are important to understanding racialized patterns of health risks, and birth outcomes specifically, over the life course and across time. While the extant literature tells the story of persistent weathering among marginalized populations, no prior study has described how this phenomenon may be changing over time. As increasing attention is given to the adverse effects of structural and cultural racism on people's health and as we push for more reparative policymaking to address health inequity, it is crucial to understand how these trends are unfolding over time.

Specific aims of Chapter 1

Empirically, the first chapter will fill three key aims:

1) assess racial disparities in the association between the age of the person giving birth and birth weight in 1990 and 2018, as well as changes over the period;
2) assess the contributions of racial differences in the distributions (i.e., endowments) of education and marital status at first birth to age patterns of very low and moderately low birth weight by race in 1990 vs. 2018; and
3) assess the contributions of racial differences in the associations (i.e., coefficients) between education and marital status at first birth with birth weight to age patterns of very low birth weight and moderately low birth weight by race in 1990 vs. 2018.

Justification for investigating the role of obstetric practices over time

Chapter two turns to the role of the medical system in producing racialized disparities in gestational age and birth weight outcomes. This chapter builds on a recent study by Tilstra and Masters (2020), which sought to explain population level declines in mean birth weight by modeling a counterfactual birth weight distribution that would have been observed in the absence of wide-spread increases in obstetric intervention. The 2020 study highlights how the joint probability of birth and obstetric intervention at specific gestational ages changed between 1990 and 2013, thus changing both the distribution of births across gestational ages and the composition of births at each gestational age (Tilstra and Masters 2020a). Importantly, however, the authors do not explore how these patterns varied by race, leaving the question of how the increasing medicalization of birth has shaped Black and White gestational age distributions and birth weights differently. Black births have consistently experienced a higher risk of both pre-term delivery and higher rates of low-risk cesarean (i.e., primary cesarean section for vertex presenting singletons to nulliparous women), which have important implications for the distribution of births by gestational age and thus birth weight. Chapter 2 will use classic demographic methods and decomposition analysis to assess the contribution of changes to GA specific rates of obstetric intervention on overall gestational length .

Specific Aims in Chapter 2:

Specifically, Chapter 2 will investigate how shifts in gestational-age-specific probabilities of birth and obstetric intervention have contributed to changes in the expected length of gestation, by race, from 1990 to 2018?

Justification for investigating the role of racialized felony disenfranchisement on birth outcomes and related risks

The third chapter will investigate the role of racialized felony disenfranchisement in shaping low birth weight risks for Black vs White births. This chapter makes an important contribution to understanding how key institutional mechanisms may operate to maintain the racial hierarchy and sequester power within dominant populations. Vast racial disparities in criminal legal system involvement are not new and they are not accidental. Patterns identified in this analysis are the consequence of policies that have been in place for nearly 200 years and have received new attention and salience in the wake of more recent mass incarceration throughout the 1980s and 1990s. Recent research has quantified the political ramifications of racialized felony disenfranchisement in swaying electoral victories in favor of a more conservative political landscape. The population under study in this analysis importantly came of age during the rise of mass incarceration and thus may have had unique exposure to the consequences of racialized disenfranchisement during critical periods throughout the life course prior to conception.

Specific Aims in Chapter 3:

Investigate the association between racialized disenfranchisement at the state level and individual level birth weight and chronic hypertension that patterns birth weight risks.

CHAPTER 1: IMPLICATIONS OF THE INTERSECTING TRENDS IN MATERNAL AGE, EDUCATION, AND MARRIAGE PATTERNS ON RACIAL BIRTH WEIGHT INEQUITIES BETWEEN 1990 AND 2018

Abstract

The weathering hypothesis posits that the effect of structural racism on health may be cumulative over the life course. While the extant literature tells the story of pervasive weathering among racially marginalized populations, with specific relevance to birth weight outcomes, no prior study has explored how contemporaneous shifts in the ages, educational attainment, and marital statuses of people giving birth may have shaped this phenomenon over time.

This study uses birth certificate data for non-Hispanic White and non-Hispanic Black singleton first births in 1990 and 2018, multinomial logistic regression, and Oaxaca-Blinder decomposition to fulfill three key aims: 1) Assess racial disparities in the association between the age of the person giving birth and birth weight in 1990 and 2018, as well as changes over the period; 2) assess the contributions of racial differences in the distributions of educational attainment and marital status at first birth to age patterns of very low and moderately low birth weight by race in 1990 vs. 2018; 3) assess the contributions of racial differences in the associations (i.e., coefficients) between

educational attainment and marital status at first birth with birth weight to age patterns of very low birth weight and moderately low birth weight by race in 1990 vs. 2018.

Taken together, results indicate a persistent weathering effect for Black births across age and time, which may be steepening over time among higher SES people. As non-marital childbearing rates increase, the importance of marital status in explaining racial differences in birth weight has waned over time, predominantly due to change in the association between marriage and birth weight for Black vs. White births. Conversely, racial differences in higher education may be contributing to a widening of racial gaps in birth weight across time, which can be attributed both to changing distributional differences in educational attainment for Blacks vs. Whites, as well as racial heterogeneity in the association of education with birth weight over time. Racial gaps are wider and the age patterns by race are more divergent for risk of very low birth weight than risk of moderately low birth weight.

Introduction

Motivated by the observation that chronic health problems such as hypertension tended to occur at earlier ages within Black populations compared to White populations in the United States, the weathering hypothesis posits that the effect of social subordination on health may be cumulative over the life course (Geronimus, 1992). A large body of research has since documented the accumulation of risk associated with chronic exposure to systemic racism and socioeconomic disadvantage throughout the life course, resulting in accelerated aging and premature onset of morbidities and mortality in populations of color (Forde et al., 2019; McDonough et al., 2015).

A well-known population test of the weathering hypothesis in 1996 documented race differences in the association between the age of the person giving birth and offspring birth weight, finding that Black people giving birth, particularly those residing in poor neighborhoods, experienced more rapidly increasing risk of offspring low birth weight with advancing age at childbirth (Geronimus, 1996). Subsequent tests of the weathering hypothesis in studies of birth outcomes have confirmed its relevance for Black people living in poor neighborhoods (Cerdá et al., 2008; Cohen, 2016; Collins et al., 2006; Love et al., 2010; Sheeder et al., 2006) and, more recently, have extended the evidence of weathering among other marginalized racial and ethnic groups (Fishman, 2020) and under a broader scope of conditions that produce chronic stress, such as physical abuse, chronic household poverty, perceived racism, and access to affordable health care (Kim et al., 2020; McDonough et al., 2015).

Meanwhile, throughout the 1990s and 2000s, mean birth weight in the United States has dropped substantially and the incidence of low birth weight and pre-term birth has risen (J. Martin et al., 2018). In the decades since the weathering hypothesis was formed, three other secular trends observed in the United States warrant a re-evaluation of the relationship between age-specific risks of adverse birth outcomes and the social hierarchy: educational expansion, delayed childbearing, and increased non-marital childbearing. While the extant literature tells the story of pervasive weathering among marginalized populations, no prior study has explored how contemporaneous demographic shifts in maternal age, education, and marriage may have shaped this phenomenon over time.

Both women's educational attainment and the average age at first birth have increased considerably for both White and Black populations. In 1990, only 11% of Black women 25 years or older had earned a college degree. By 2020, that number had nearly tripled to 31%. White women with a college degree also more than doubled from 19% in 1990 to 42% in 2020 (US Census Bureau). While more people than ever before are attending and completing college, marriage rates have been steadily declining since 1980, reaching a record low of 6.5 marriages per 1,000 population in 2018 (Curtin, 2020), with widely different patterns for Black and White Americans. Over half of Black millennials and 20% of White millennials are projected to remain never married by the age of 40 (S. Martin et al., 2014).

Even with simultaneous increases in non-marital childbearing, delays in marriage and increases in educational attainment mean that families are being formed later in the life course. In 2018, the mean age at first birth was 26.9 years, which was a record high for the nation at the time and an increase of over 3 years since 1990. Still, in 2018, the mean age at first birth was nearly 3 years older for White mothers at 27.3 years compared to Black mothers at 24.5 years. Non-marital childbearing is highest among Hispanic and non-Hispanic Black mothers and, while in the middle of the 20th century non-marital births were overwhelmingly born to teenage mothers, by 2018 only 26% of non-marital births were to mothers under the age of 20 (National Center for Health Statistics). Taken together, these population-level shifts may have implications for shaping racialized patterns of health risks over the life course and across historical time.

Racialized patterns of family structure and the marriage-health relationship

A large body of research has linked marriage to improved mental and physical health outcomes for adults (Gove et al., 1983; Waite, 1995), however results are mixed when considering the intersecting social structures of race, class, and gender. For example, Susan Roxburgh (2014) found that marriage was associated with lower rates of depression for White Americans and higher rates of depression for Black men and affluent Black women. The study also found that marriage was associated with better health outcomes for low-income White Americans, but these benefits were not experienced by Black Americans, challenging the conventional wisdom that marriage is good for your health.

Reasons for differential returns to marriage by race and class are varied, with some research indicating that Black and low SES marriages may be subject to higher levels of marital strain and disruption (Broman, 1993; Umberson et al., 2005; Western, 2004) and that the economic gains from marriage are unequally distributed by race (Willson, 2003). Another body of research suggests that racial differences in extended family and community embeddedness may attenuate the independent effect of marriage and family structure on wellbeing (Cross, 2020; Jayakody et al., 1993; Sarkisian & Gerstel, 2004; Taylor, 1986) and thus narrow the gap in social disadvantage between married and unmarried Black women.

Lastly, the socio-economic stress hypothesis, often used to explain racial differences in the relationship between parental absence and child wellbeing, claims that the deleterious effects of parental absence may be less pronounced in groups that face many other compounding socioeconomic disadvantages (Cross, 2020). Therefore, population level shifts in marriage rates and non-marital childbearing may not have the same impact across groups with disparate levels of stress associated with socioeconomic disadvantage and systemic racism.

Racialized patterns of education and health

As a strong indicator of socioeconomic status, education has consistently been linked to health in studies on social determinants and fundamental causes of health disparities among social groups. Central to fundamental cause theory is the notion that socioeconomic status either promotes or restricts access to "flexible resources" that affect individual health outcomes (Link & Phelan, 1995). An extension of the fundamental cause theory in 2015 articulated how racism specifically structures access to flexible resources ranging from a) unequal representation in positions of power (e.g., within government, law enforcement, medical, or financial institutions) to b) individual resources of money, knowledge, power, and prestige that are disproportionately held by Whites or c) the social psychological advantages inherently provided by living in a society predicated on White supremacy (Phelan & Link, 2015). Considering widespread increases and yet persistent racial disparities in educational attainment in the United States over the past several decades, further exploration of how the value of education as a flexible resource for maternal and newborn health gains may be changing over time and across groups.

The diminishing returns hypothesis was first established to explain a phenomenon whereby racially minoritized groups received diminishing economic returns to increasing educational attainment (Bowles and Gintis 1976) and has since been applied to explain racial differences in the socioeconomic gradient observed across various health outcomes (Boen 2016; Farmer and Ferraro 2005; Turner et al. 2016). The economic and social resources conferred by educational attainment are fundamental to the maintenance of health across the life course (Link and Phelan 1995) and there is overwhelming evidence that these resources are not only inequitably distributed, but also confer diminishing returns to health for racially minoritized groups (Assari 2018). However, in the wake of rapid educational expansion, there is less understanding of how changes to the racial distribution of education as well as racial heterogeneity in the association between education and birth weight have contributed to race gaps in birth weight over time.

Aims

This paper aims to fill key gaps in our understanding of trends in low birth weight in the United States, paying particular attention to how shifts in the distribution of age, educational attainment, and marital status at first birth have shaped the age patterns of birth weight outcomes by race over time. In light of recent delays in childbearing to later ages, expanding educational attainment prior to birth, and increased non-marital childbearing, this paper will take a long-term look at the relationship between race, age, and birth weight between 1990 and 2018 to address three key research aims:

1) Assess racial disparities in the association between the age of the person giving birth and birth weight in 1990 and 2018, as well as changes over the period;

2) assess the contributions of racial differences in the distributions of age, educational attainment, and marital status at first birth to racialized patterns of very low and moderately low birth weight in 1990 vs. 2018; and

3) assess the contributions of racial differences in the associations (i.e., coefficients) between age, educational attainment, and marital status with birth weight to racialized patterns of very low birth weight and moderately low birth weight in 1990 vs. 2018.

Data and Methods

Data and Sample

This analysis uses completed birth certificates for singleton first births to US-born non-Hispanic White and non-Hispanic Black mothers in 1990 and 2018 as reported in the public use birth record data by the National Center for Health Statistics (NCHS). I exclude multiple births and higher order births from the analysis to remove confounding of both multiple births and parity on birth weight. Because my analysis looks at the contributions of educational attainment prior to first birth, I restrict my sample to mothers who are at least 23 years old at the time of birth and have thus reached the age at which it is possible to have obtained a college degree before birth. Births to younger people may interrupt ongoing educational attainment, thus making the socioeconomic significance of education less interpretable at the time of birth.

I exclude observations for which there is missing information on birth weight (1,423, 0.08%), gestational age (6,658 observations; 0.43%), maternal ethnicity (32,875 observations; 1.91%), maternal education (83,577 observations; 4.61%) and/or marital status (53,240 observations; 2.57%). Finally, according to convention, I excluded 320 observations with implausible birth weights more than 5 standard deviations above or below the gestational-age-specific median (Joseph et al., 2001). I also exclude births with a recorded gestational age later than 44 weeks or earlier than 21 weeks (19,450 observations; 1.08%), which is when the American College of Obstetricians and Gynecologists define the start of peri-viability (ACOG 2017).

The final sample includes 1,252,600 singleton first births, including 660,773 births in 1990 and 591,827 births in 2018. I conducted sensitivity analyses to assess the impact of missing data, including assessing the age patterns of birth weight by race for complete data vs. the full data set in each year and running the analysis with multiple imputation of missing values. The patterns described below were largely unchanged in these analyses and thus I conducted the final analysis using listwise deletion of incomplete observations.

Measures

The key dependent variable is a three-level categorical variable of very low birth weight, moderately low birth weight, and normal birth weight. Very low birth weight is defined as a newborn weighing less than 1500 grams or 3.3 pounds and moderately low birth weight is defined as a newborn weighing between 1500 and 2499 grams or 3.3 and 5.5 pounds. The reference category of normal birth weight includes all newborns weighing at least 2500 grams (5.5 pounds). Most studies of birth weight use either a binary variable of low birth weight (2500 grams or less) or a continuous variable to assess differences in group means. However, during exploratory analysis of the data, racial disparities were most heavily concentrated at the lowest birth weight quantiles where babies are at highest risk of morbidity and mortality. Thus, I felt it was important to look more granularly at very low and moderately low birth weight separately.

Key independent variables are year of birth (1990 vs. 2018), race/ethnicity (non-Hispanic White=0, non-Hispanic Black=1), maternal age, maternal education, and marital status at birth. Age is categorized into five groups from 23-24, 25-29, 30-34, 35-39, and 40+. The upper bound includes all births up to age 49. The handful of observations recorded above age 49 were excluded from the analysis. Educational attainment is collapsed into three-categories: high school or less, some college, or college degree and higher. Alternative operationalizations of educational attainment, such as separating those who did not finish high school or a those who obtained a graduate degree, did not yield meaningfully different results. Marital status is a binary variable for married or unmarried, with no accounting for non-marital cohabitation due to data limitations.

Methods

To address the first research aim regarding racial disparities in the association between maternal age and birth weight across the period, this study uses multivariate multinomial logistic regression models to predict the relative risk of very low and moderately low birth weight by maternal age, race, and year and their two and three-way interactions in the base model. In model 2, I include educational attainment and two- and three-way interactions with race and year. In model 3, I include marital status as well as two- and three-way interactions between marital status, race, and year. Finally, model 4 combines all covariates and interaction terms. Exponentiated regression coefficients are reported as relative risk ratios for ease of interpretation.

I then estimate predicted probabilities of very low and moderately low birth weight by race and age in each year, stratified by educational attainment and marital status and plot these using the margins and margins plot commands in Stata 17. Predicted probabilities for education are generated from model 2 (not adjusted for marital status) and probabilities for marital status are generated from model 3 (not adjusted for educational attainment). I then plot both the absolute difference in Black-White probabilities by age group and year and the Black-White ratio of predicted probabilities to assess how race gaps in risk of very low and moderately low birth weight are changing across age and historical time in both absolute and relative terms.

Finally, to address the second and third research aims, I conduct Oaxaca-Blinder style decompositions of racial gaps in probability of very low birth weight and moderately low birth weight in 1990 and 2018 separately (Equation 1.1). I then perform non-parametric bootstrap estimation of the 1990 and 2018 decompositions combined and perform Wald tests to assess statistical significance of the change in the explanatory variables' endowments and coefficients of the Black-White gap over time.

$$Y_B - Y_W = \overbrace{(\overline{X_W} - \overline{X_B})'\widehat{\beta_W}}^{\text{Endowment}} + \overbrace{(\hat{\beta}_W - \hat{\beta}_W)\bar{X}'_B}^{\text{Coefficient}} \tag{1.1}$$

While the decomposition results use the same analytic sample and are complementary to the multinomial logistic regression results presented in Tables 1.2a-b, they do not represent a direct decomposition of those regressions. The regressions underlying the decomposition are generated using Stata 17 and the oaxaca command for non-linear regression on very low birth weight and moderately low birth weight separately, each using normal birth weight (2,500 grams or higher) as the reference group.

For ease of interpreting the decomposition results, I included age as a continuous variable with values between 23-49 years and dichotomized education to represent whether or not the person giving birth had a Bachelor's degree prior to birth. This cut point was chosen both because of the reductions in risk for those with college degrees, but also because of the theoretical significance of a college education in the era of educational expansion. I adjust the decompositions for the interaction between age and education, understanding that the births to more highly educated mothers likely skew older. Marital status is recorded as a binary variable for married vs. unmarried on US birth certificates and thus was already dichotomous.

Endowment figures represent the portion of the *Black*-White gap in probability of VLBW or MLBW that is attributable to racial differences in the distribution of these variables (i.e., the percentage of each group that is over 30, married, and/or college-educated). The coefficient figures represent the portion of the racial gap that is attributable to racial differences in the association between each factor and very low or moderately low birth weight.

Results

Descriptive Findings

Table 1.1 compares the characteristics of births in the analytic sample in 1990 to births in 2018, by race. Over this time, mean birth weight decreased by 79 and 77 grams for White and Black infants, respectively. Both very low birth weight and moderately low birth weight increased. In 2018, 3.5% of Black babies were born very low birth weight, a rate more than triple the 1% of White births born under 1500grams and up half a percentage point from 3.0% in 1990. Similarly, Black births were more than twice as likely as white births to be born moderately low birth weight (10.8% vs. 5.2% in 2018).

Maternal age increased for both groups. Among White people giving birth at or above the age of 23 in 1990, the mean age was 28.2 years. This increased by 1.3 years to 29.5 years in 2018. The mean age for Black people in the sample increased by less than one year from 27.4 to 28.1 years of age. Note, however, that this table is not representative of the mean age of first birth for these general populations, as the sample for this study is restricted only to birthing people aged 23 years of age and older.

Maternal education shifted drastically between 1990 and 2018, with the percentage of births to college-educated people 23 years and older growing from 37% in 1990 to 57% in 2018 for White birthing people and 23% to 32% among Black birthing people. However, it should also be noted that because I only include births to people 23 years of age or older, these rates are higher than the general population of first births. Non-marital childbearing also increased for both Black and White people by +22% points and +14% points respectively. Black people remain far less likely than White people to be married at the time of birth, with only 28% of Black people married at first birth, compared to 77% of White people in 2018. The relative increase in non-marital childbearing for White people, however, was more substantial, more than doubling from 10% in 1990 to 23% in 2018. Chi-square and t-tests of significance for changes in proportions and means indicated that all reported changes between 1990 and 2018 in sample characteristics were statistically significant at the $p<0.001$ level.

Figure 1.1 A-C provide graphical representations of the cross-tabulations provided in Table 1.1 to demonstrate evidence of three secular trends relevant to a re-evaluation of the weathering hypothesis.

Empirical Findings

Multinomial Logistic Regression Analysis of Very Low and Moderately Low Birth Weight in 1990 and 2018

The multinomial logistic regression analyses in Table 1.2a on very low birth weight and in Table 1.2b on moderately low birth weight, reveals that, net of age and race, the risks of both very low and moderately low birth weight are about 30% higher in 2018 than they were in 1990 (p<0.001). Net of age, Black births to people over 23 years old in 1990 experienced nearly 4 times the risk of very low birth weight (RRR=3.86; p<0.001) and over 2 times the risk of moderately low birth weight (RRR=2.28, p<0.001) compared to White births in the same year. After accounting for both educational attainment and marital status, the risk for very low birth weight remained over twice as high and the risk for moderately low birth weight remained over 70% higher for Black births compared to White births.

As expected, the risk of both very low birth weight and moderately low birth weight increased with age for both Black and White people giving birth. The effect of increasing age on risk of both very low birth weight and moderately low birth weight did attenuate slightly by 2018, particularly for people in their 30s, who experienced a 23-

26% reduction in risk of very low birth weight and a 20% reduction in risk of moderately low birth weight. Consistent with the weathering hypothesis, the growing risk of low birth weight for older Black people giving birth emerges earlier and increases more steeply with age than it does for White people, especially for risk of very low birth weight. The modifying effect of age on risk of moderately low birth weight for Black people giving birth is slightly weaker than it is for very low birth weight risk and largely disappears after accounting for educational attainment. The relationship between race and age on risk of moderately low birth weight is slightly larger in magnitude by 2018 relative to 1990, however the change is not statistically significant (Age 30-34 RRR=1.10; p=0.10), suggesting a stagnation in the weathering process across time. However, between 1990 and 2018, the relationship between race and age on risk of very low birth weight steepened for Black people giving birth between 30-39 years of age (RRR for Age 30-34 = 1.30, p=0.01; RRR for Age 35-39 = 1.34; p=0.03).

Education

Education is associated with reduced risk of both very low birth weight and moderately low birth weight, with people who attained a college education prior to giving birth experiencing about a 40% lower risk for either outcome than those with a high school education or less (p<0.001). For Black people, the returns to education are lower than for White people. A Black person with a college education prior to first birth in 1990 was 16% and 12% more likely to have a very low or moderately low-birth-weight birth, respectively, than a White person giving birth with the same level of education. By 2018, those relative risks had increased to 23% and 18% respectively, however, the change was not statistically significant across time. The overall association between a college education and reduced risk of very low birth weight grew by 24% between 1990 and 2018 (RRR=0.76; p<0.001), while the protection conferred to college-educated Black people giving birth remained lower compared to their White counterparts. The association between a college education and reduced risk of moderately low birth increased by just 5% over the period and this change was only marginally significant (RRR=0.95; p=0.06).

Figure 1.2 provides predicted probability plots of very low and moderately low birth weight by race and age in 1990 (solid lines) vs. 2018 (dashed lines), separately for each educational category. These plots show a clear educational gradient in the race and age-specific risks of low birth weight that is persistent across time. The largest increases in risk over time, particularly for very low birth weight, have been among Black people with less than a college education. Thus, the lower relative risk ratio associated with a college education in 2018 compared to 1990 is likely a function not of lower risks among those with a college education but rather of higher relative risks experienced by those with a high school education or less.

Figure 1.3 plots the Black-White risk ratio and absolute difference in Black vs. White predicted probabilities, by race and age for people with a high school education or less (in red) vs. people with a college education (in black) in 1990 (solid lines) and 2018 (dotted lines). The racial gap in risk of both very low birth weight and moderately low birth weight in both time points increases with advancing age at childbirth, suggesting persistent weathering across age and time. However, while the absolute gap in Black-White risk of very low birth weight has increased between 1990 and 2018 (See Figure 1.3, Panel B), the Black-White risk ratio has decreased at all ages among those with lower education and at both younger (23-29) and older (40+) age among those with a college education (Panel A).

The Black-White gap in risk of moderately low birth weight has narrowed for those with a high school education or less, with the largest narrowing observed at the oldest ages. The Black-White gap in moderately low birth weight has widened between 1990 and 2018 for those with a college education. When looking at change to the Black-White risk ratio, however, relative risks of moderately low birth weight have narrowed between 1990 and 2018 for those with a high school education or less, among whom Whites experienced a larger increase in risk across all ages.

Marriage

The results of the multinomial logistic regression indicate that, net of race, age, and education, being married at the time of birth was associated with a 43% reduction in the risk of very low birth weight ($p<0.001$) and a 37% reduction in risk of moderately low birth weight in 1990. However, this association has weakened substantially over time. In 2018, married individuals were only 23% less likely to have a first birth born either very low or moderately low birth weight (p<0.001) compared to unmarried individuals.

Like education, marriage was more protective for White births than Black births. In 1990, the relative risk ratio of very low birth weight for Black births to married vs unmarried people was 40% higher than the ratio for White births to married vs. unmarried people (p<0.001). However, with the overall decline in the protective association of marriage with birth weight over time, the racial gap in the association between marriage and very low birth weight has also narrowed over the period. By 2018, there was no significant Black-White difference in the reduction of very low birth weight risk associated with marriage. Still, the diminished returns to marriage for Black births remained evident for moderately low birth weight in both years, with no significant change over time.

Figure 1.4 provides the relative and absolute racial differences in risk of very low and moderately low birth weight by marital status across maternal age groups in 1990 vs. 2018. The absolute differences show Black-White gaps in risk increase with age for births to both married and unmarried people and these gaps are larger in 2018 than in 1990 for very low birth weight. The Black-White gaps in moderately low birth weight decreased overall between 1990 and 2018 for unmarried women and increased for married women. While the absolute difference in Black-White risk increased with age and remained highest among unmarried women, the Black-White risk ratio was highest for married women.

Decomposition of Differential Exposure vs. Differential Associations by Race

Table 1.3 details the decomposition of racial gaps in the probability of very low and moderately low birth weight that is attributable to racial differences in exposure to different maternal age groups, non-marital childbearing, and college education versus that which is attributable to racial heterogeneity in the association of these exposures with birth weight. In 1990, nearly 3% of Black births were very low birth weight while less than 1% of White births were very low birth weight. The White-Black gap in probability of very low birth weight significantly increased from 2.6 percentage points in 1990 to 3.2 percentage points in 2018 ($p<0.001$).

Risk of moderately low birth weight was also significantly higher among Black births at 11% compared to White births at 4.8%. The racial gap in probability of moderately low birth weight also increased by 0.4 percentage points between 1990 and 2018, but the increase was not statistically significant ($p=0.19$). While the bulk of the racial gap is attributable to intercept differences between the two groups (i.e., based solely on group membership and otherwise unexplained by the variables in the model), a significant amount of the gap can be explained by racial differences in age, education, and marriage.

Contribution of Age at Birth to Race Gaps in Low Birth Weight

In both years, the distribution of age at birth contributed negatively to the racial gap in both very low and moderately low birth weight risk, which indicates that Black women were more often giving birth at ages associated with reduced risk of low birth weight. This is expected given the age gradient of risk and lower-average maternal age for Black compared to White birthing people. Racial differences in the association between age and very low birth weight contributed 2% of the racial gap in 1990 and 5% of the racial gap in 2018, suggesting a growing divergence in age patterns of risk of very low birth weight for Black vs. White birthing people ($p<0.001$). Racial differences in the association between age and moderately low birth weight did not make a significant contribution to racial gaps in the outcome at either time point.

Contribution of Marital Status at Birth to Race Gaps in Low Birth Weight

Consistent with the multinomial logistic regression results, marital status contributed more to racial gaps in risk of low birth weight in 1990 than in 2018. Looking at the decomposition analysis, we can disentangle how much of the gap is attributable to lower rates of marriage among Black mothers and how much is attributable to Black women benefitting less than White women from being married. In 1990, marital status overall contributed 23% of the racial gap in very low birth weight risk, of which 10% was attributable to racial differences in marriage rates and 13% was attributable to diminished returns to marriage for Black women. By 2018, a significantly smaller portion of the gap was explained by marriage ($p<0.001$), with only 5% of the gap attributable to racial differences in exposure to marriage and 2% attributable to racial differences in the association between marital status and birth weight.

Marriage also contributed to racial gaps in moderately low birth weight, with a larger contribution from racial differences in exposure to marriage, which contributed 16% of the gap in 1990. Racial differences in the protective effect of marriage also contributed an additional 5% to the total gap in 1990. The contribution of marriage to racial gaps in moderately low birth weight did not change significantly between 1990 and 2018.

Contribution of Higher Education to Race Gaps in Birth Weight

Table 1.1 and Figure 1.1A demonstrate substantial increases in the proportion of mothers receiving at least a Bachelor's degree prior to first birth as well as vast racial disparities in educational attainment by race. Thus, it is unsurprising that racial differences in education endowments contribute significantly to the racial gap in risk of both very low birth weight and moderately low birth weight in both time periods and that the contribution grows significantly over time. However, racial differences in the association between college and risk of very low birth weight is only significant in 2018, increasing from 2% of the gap in 1990 to 6% of the gap in 2018 and comprising 20% of the total increase in the gap in risk of very low birth weight over time ($p<0.01$). Racial differences in education coefficients also contribute significantly to racial gaps in risk of moderately low birth weight in each year, but the association does not change significantly over time, contributing 3% of the gap in 1990 and 4% of the gap in 2018.

Discussion

This study has shown that increasing risk of low birth weight with advancing maternal age among Black women is persistent across time and, in absolute terms, the weathering effect on risk of very low birth weight appears to have worsened over time. There has been an increase in the absolute gaps between Black and White risk of very low birth weight for all educational and marital status groups and these gaps widen substantially as maternal age increases, particularly for women with low education and among those who are unmarried. Change to the weathering effect on risk of moderately low birth weight over time is less consistent.

While Black-White gaps in risk clearly widen across maternal age in both time periods and for all groups, further steepening of the age gradient over time only appear in groups with higher education and among those who were married, suggesting a diminishment in the protective value of these social institutions for Black women relative to White women over time. Among both unmarried women and women with a high school education or less, the widening of racial gaps in risk of moderately low birth weight with age slowed down over time (i.e., their age slopes were more similar in 2018 compared to 1990).

While the overall risk for each group has increased over time and the absolute gaps between groups have increased, particularly at older ages, the relative risks to Black vs. White births have mostly decreased between 1990 and 2018. The only increases in relative risk of very low birth weight across maternal age groups appears among unmarried women, with the ratio of Black unmarried risk to White unmarried risk increasing substantially between age 30-39. Racial differences in the returns to marriage have clearly narrowed across time. In 1990, married Black women had a predicted probability of very low birth weight that was four times that of married White women at age 30, while unmarried Black women had a predicted probability of very low birth weight that was just over 2.5 times the probability among unmarried White women. By 2018, these risk ratios had begun to converge at 3.5 and 3.2 respectively.

A large body of research links birth weight to long-term health outcomes and thus understanding the mechanisms and social processes that produce racial disparities in birth outcomes is important to understanding health patterns across the life course. This work makes an important contribution to research on both the weathering hypothesis and the diminishing returns hypothesis as it relates to racial disparities in birth outcomes and health more broadly. The weathering hypothesis provides a useful framework for understanding the erosive consequences of living in a society that is predicated on White supremacy. The cumulative effects of exposure to widespread cultural and structural racism are expressed in the earlier onset of morbidities and mortality within the life course. From a life course perspective, the effect of weathering on birth outcomes has implications for every subsequent stage of development as well as intergenerational and epigenetic transmission of risk among racially minoritized populations.

Limitations

This study is not without limitations. By only including observations with complete data, I am potentially looking at a sample that is lower risk than the full population, as births to people who are more marginalized in society, may have both more risk factors for adverse birth outcomes and be less likely to receive attentive care and record keeping. If so, this would make the results more conservative than what is presented here. I did sensitivity analyses to test whether birth weight patterns by race and age were changed by including observations that were missing marital status and/or education and did not find any significant differences in the results. I also performed multiple imputation with chained equations on missing data and this also did not change the results. Thus, I do not believe missingness has introduced significant bias into my findings.

Another limitation of this paper is the lack of subnational analyses. Given the diversity of social, political, and cultural contexts across different cities, states, and regions in the United States, it is probable that a national-level inquiry masks underlying heterogeneity across subnational geographies. The third chapter of this dissertation will consider state and county-level contextual factors, but there is ample opportunity for further research on this topic at a more granular level. Future research should also expand beyond Black-White gaps to look at other racial/ethnic groups and axes of stratification, such as nativity.

Finally, the weathering hypothesis is potentially complicated by selection bias for age at first birth. People who either opt to delay pregnancy to later ages and/or who took longer to get pregnant and are thus older at the time of first birth may be inherently different than people who opt for earlier childbearing. Thus, while the weathering hypothesis posits that the steeper increase in risk for Black births with advancing maternal age is due to cumulative stress processes over the life course, there may also be health-related selection into later childbearing that varies by race. Without data on previous infecundity, it is difficult to test this alternative hypothesis. However, by accounting for educational attainment, which is a common reason for delayed childbearing that is unrelated to fecundability, the reasons for delay among groups being compared are likely less biased.

Conclusion

Decades after researchers identified the earlier onset of morbidities and mortality among racially and economically marginalized groups, these patterns remain salient to racial disparities in birth weight. This study identified three factors that convey an important linkage between life course weathering and diminished returns to social resources for racially minoritized groups: Age, education, and marriage. Shifts in the racial patterns of both educational attainment and marital status contribute to age patterns of childbearing and the race and age-specific risks of very low and moderately low birth weight. While marriage appears to be contributing less to racial disparities in birth weight over time, racial differences in educational attainment and further diminishment of returns to education for Black women may have a widening effect on Black-White gaps in birth weight over time. Understanding these patterns is important for understanding the impact of large social institutions like marriage and education on racial health disparities and how large demographic shifts may attenuate or exacerbate the influence of these institutions on the population over time.

As both the level and nature of participation in higher education and marriage evolve, the timing and significance of their influence on people's lives and health may also evolve. As educational attainment expands, the population with no college education may be selectively higher risk over time. Similarly, as more people forego or delay marriage until after bearing children, the population of people who are unmarried at first birth may become selectively lower risk over time.

There is broad racial variation in the distribution of maternal age, education, and marriage which have been persistent across time. However, there is also racial heterogeneity in the association of these factors with birth weight that also contribute to racial gaps in birth weight. Understanding why marriage is not equally beneficial for Black and White people can help shape better policies that promote racial equity in the returns to marriage. For example, Dorothy Brown in her recent book "The Whiteness of Wealth" notes how, because Black women contribute about half of family income in a dual earner household while White women contribute far less to dual earner households on average, marriage and filing joint tax returns often translates to tax increases for Black families and tax decreases for White families (Brown 2021). Thus, updating such a seemingly race neutral thing as the tax code with racial equity in mind may be a step in the right direction toward more equitable health risk reduction.

We also see that both the distribution and the returns to education are racially unequal. Therefore, policies that both promote more equal access to higher education in Black communities and ensure that higher education can be translated into higher earnings and improved life chances are important. Promoting more equal access starts with more equitable college preparation in primary and secondary education. Furthermore, making college more affordable could also help level both sides of this equation by lowering the financial bar for entry and the debt burden that is disproportionately held by former Black college students and graduates.

Chapter 1 Tables and Figures

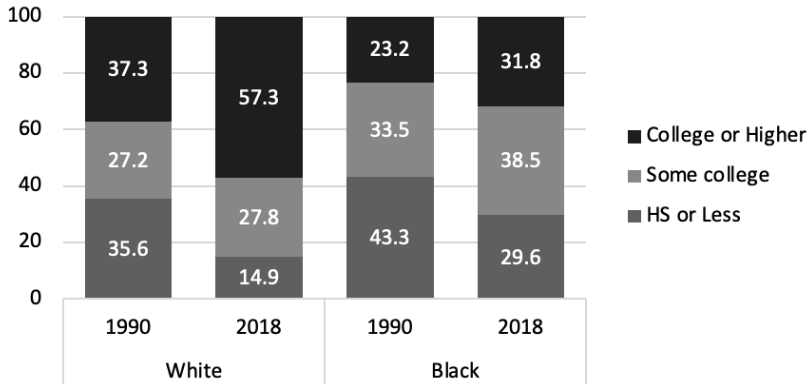
TABLE 1.1 Chapter 1 Sample Characteristics, by Race and Year[1] (N=1,252,634)

	White			Black			Total		
	1990	2018		1990	2018		1990	2018	
	%; µ (sd)	%; µ (sd)	Δ	%; µ (sd)	%; µ (sd)	Δ	%; µ (sd)	%; µ (sd)	Δ
Birth Weight Category									
VLBW[2]	0.8	1.0	0.2 ***	3.0	3.5	0.5 ***	1.0	1.3	0.3 ***
MLBW[3]	4.4	5.2	0.8 ***	9.6	10.8	1.2 ***	4.9	6.0	1.0 ***
Normal[4]	94.8	93.8	-1.0 ***	87.5	85.7	-1.7 ***	94.0	92.7	-1.4 ***
Mean Birth Weight	3395.0	3316.2	-78.7 ***	3120.3	3043.6	-76.6 ***	3365.8	3276.7	-89.2 ***
	(557.4)	(550.2)		(657.5)	(654.6)		(575.1)	(574.6)	
Maternal Age									
23-24	18.4	13.3	-5.1 ***	27.9	25.8	-2.0 ***	19.4	15.1	-4.3 ***
25-29	49.0	40.6	-8.5 ***	47.0	42.9	-4.1 ***	48.8	40.9	-7.9 ***
30-34	24.6	33.0	8.3 ***	19.2	20.3	1.1 ***	24.1	31.1	7.1 ***
35-39	7.1	11.2	4.1 ***	5.3	8.9	3.6 ***	6.9	10.9	4.0 ***
40+	0.9	2.0	1.1 ***	0.7	2.1	1.4 ***	0.9	2.0	1.1 ***
Mean maternal age	28.2	29.5	1.2 ***	27.4	28.1	0.7 ***	28.1	29.3	1.1 ***
	(3.9)	(4.3)		(3.9)	(4.5)		(3.9)	(4.4)	
Maternal Education									
HS or Less	35.6	14.9	-20.7 ***	43.3	29.6	-13.6 ***	36.4	17.1	-19.3 ***
Some college	27.2	27.8	0.7 ***	33.5	38.5	5.0 ***	27.8	29.4	1.5 ***
College +	37.3	57.3	20.0 ***	23.2	31.8	8.6 ***	35.8	53.6	17.8 ***
Marital Status									
Unmarried	9.8	23.3	13.6 ***	50.1	71.7	21.6 ***	14.0	30.3	16.3 ***
Married	90.2	76.7	-13.6	49.9	28.3	-21.6	86.0	69.7	-16.3
N	590,708	505,942		70,103	85,881		660,811	591,823	

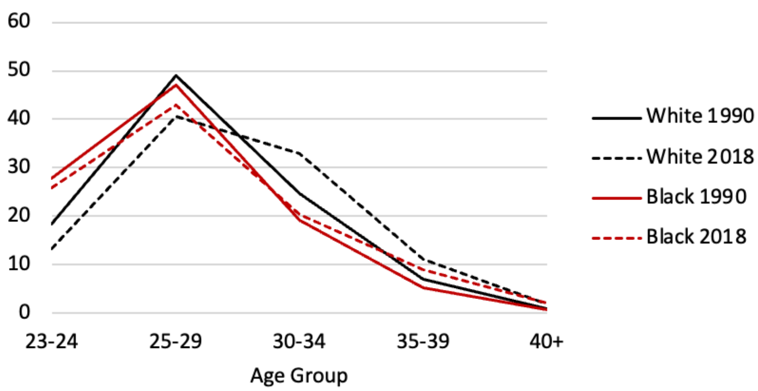
[1] For categorical and binary variables, p-values are derived from race-specific chi-square tests of change in proportions over time. For continuous variables, p-values are derived from t-tests of change in means over time. *** indicates p<0.001 [2] Very low birth weight (VLBW) is defined as a newborn weighing less than 1,500 grams or 3.3 pounds at the time of birth. [3] Moderately low birth weight (MLBW) is defined as a newborn weighing between 1,500 and 2,499 grams or 3.3 and 5.5 pounds at the time of birth. [4] Normal birth weight is defined as a newborn weighing at least 2,500 grams or 5.5 pounds more at the time of birth.

FIGURE 1.1: Evidence of Educational Expansion, Delayed Childbearing, and Increased Non-Marital Childbearing, by Race and Year

(A) **Educational Expansion:** Percentage Distribution of Educational Attainment by Race and Year



(B) **Delayed childbearing:** Maternal age distribution of first births for people aged 23-49 at first birth, by Race and Year



(C) Non-Marital Childbearing: Percentage of first births to people aged 23-49 who are unmarried, by race and year

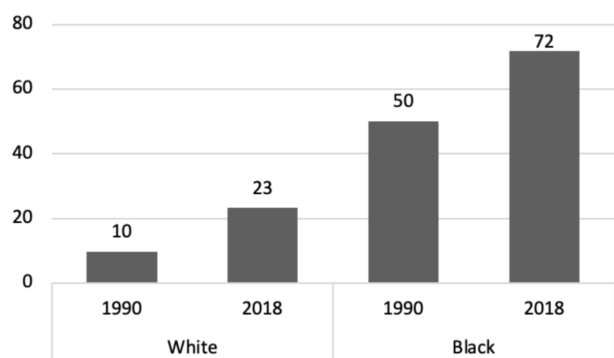


TABLE 1.2a: Relative Risk Ratios of Very Low Birth Weight (<1,500g), by Race, Age, Education, and Marital Status, 1990 vs. 2018

		Base Model (Race, Age)						Full Model[1] (Race, Age, Education, Marriage)					
		1990		2018		Δ1990 to 2018[2]		1990		2018		Δ1990 to 2018[2]	
Black		3.86 ***	(0.22)	3.11 ***	(0.18)	0.81 **	(0.06)	2.48 ***	(0.17)	2.52 ***	(0.16)	1.01	(0.10)
Age:	23-24	1.00	--	1.00	--	1.00	--	1.00	--	1.00	--	1.00	--
	25-29	0.90 *	(0.04)	0.90 **	(0.04)	1.00	(0.06)	1.04	(0.04)	1.16 **	(0.05)	1.11 ~	(0.07)
	30-34	1.23 ***	(0.06)	0.95	(0.04)	0.77 ***	(0.05)	1.50 ***	(0.07)	1.43 ***	(0.07)	0.95	(0.06)
	35-39	1.75 ***	(0.10)	1.30 ***	(0.07)	0.74 ***	(0.06)	2.16 ***	(0.13)	1.94 ***	(0.11)	0.90	(0.07)
	40+	2.31 ***	(0.26)	2.04 ***	(0.17)	0.88	(0.12)	2.83 ***	(0.32)	3.00 ***	(0.25)	1.06	(0.15)
Black*Age:	23-24	1.00	--	1.00	--	1.00	--	1.00	--	1.00	--	1.00	--
	25-29	1.14 ~	(0.08)	1.28 ***	(0.09)	1.13	(0.11)	1.06	(0.08)	1.10	(0.08)	1.03	(0.10)
	30-34	1.20 *	(0.09)	1.56 ***	(0.11)	1.30 *	(0.14)	1.11	(0.09)	1.29 **	(0.10)	1.16	(0.13)
	35-39	1.05	(0.11)	1.41 ***	(0.12)	1.34 *	(0.19)	0.98	(0.11)	1.24 *	(0.11)	1.27 ~	(0.18)
	40+	1.05	(0.24)	0.91	(0.13)	0.87	(0.24)	0.98	(0.23)	0.83	(0.12)	0.85	(0.23)
Education	Less than HS							1.00	--	1.00	--	1.00	--
	Some College							0.76 ***	(0.03)	0.72 ***	(0.03)	0.95	(0.05)
	College+							0.61 ***	(0.02)	0.47 ***	(0.02)	0.76 ***	(0.04)
Black*Education:	Less than HS							1.00	--	1.00	--	1.00	--
	Some College							1.19 **	(0.08)	1.11 ~	(0.07)	0.94	(0.08)
	College+							1.17 *	(0.09)	1.23 **	(0.08)	1.05	(0.10)
Married								0.57 ***	(0.02)	0.77 ***	(0.03)	1.36 ***	(0.07)
Black*Married								1.39 ***	(0.09)	1.09	(0.06)	0.78 **	(0.07)
Intercept		0.01 ***	(0.00)	0.01 ***	(0.00)	1.37 ***	(0.07)	0.01 ***	(0.00)	0.02 ***	(0.00)	1.11	(0.07)

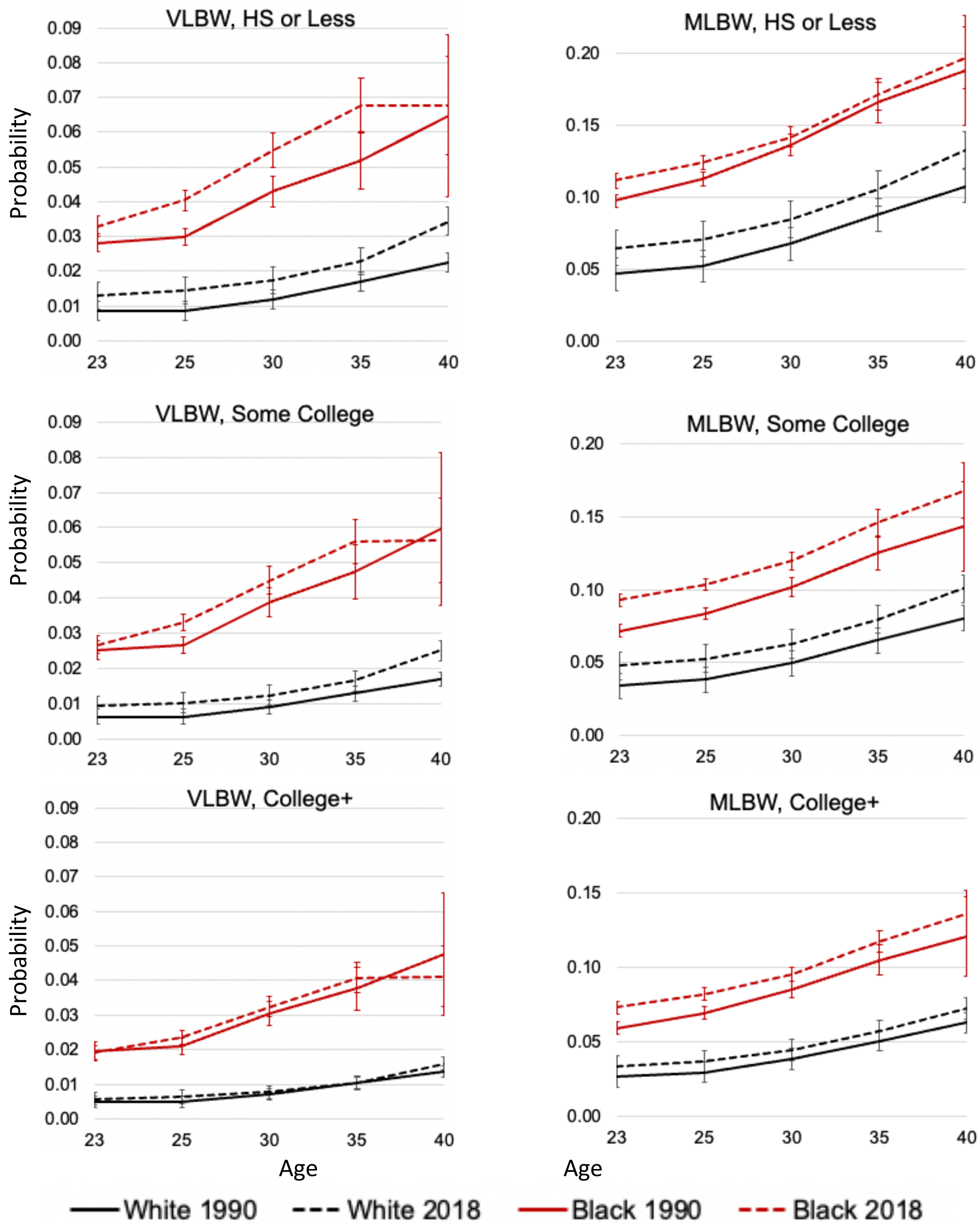
***p<0.001; **p<0.01; *p<0.05; ~p<0.10; [1]Stepwise multinomial logistic regression models that look at marital status and education separately are available the appendix. 2 To simplify interpretation, these multinomial logistic regressions are stratified by year and the coefficients for change over time are drawn from separate models using the pooled 1990 and 2018 data that include two and three-way interactions with year.

TABLE 1.2b: Relative Risk Ratio of Moderately Low Birth Weight (1,500-2,499g), by Race, Age, Education, and Marital Status, 1990 vs. 2018

		Base Model (Race, Age)						Full Model[1] (Race, Age, Education, Marriage)					
		1990		2018		Δ1990 to 2018[2]		1990		2018		Δ1990 to 2018[2]	
Black		2.28 ***	(0.07)	2.08 ***	(0.06)	0.91 *	(0.04)	1.74 ***	(0.06)	1.71 ***	(0.06)	0.98	(0.05)
Age:	23-24	1.00	--	1.00	--	1.00	--	1.00	--	1.00	--	1.00	--
	25-29	1.01	(0.02)	0.93 ***	(0.02)	0.92 **	(0.03)	1.16 ***	(0.02)	1.14 ***	(0.02)	0.99	(0.03)
	30-34	1.25 ***	(0.02)	1.00	(0.02)	0.80 ***	(0.02)	1.53 ***	(0.03)	1.41 ***	(0.03)	0.92 **	(0.03)
	35-39	1.61 ***	(0.04)	1.30 ***	(0.03)	0.81 ***	(0.03)	2.01 ***	(0.05)	1.80 ***	(0.05)	0.90 **	(0.03)
	40+	1.98 ***	(0.11)	1.69 ***	(0.07)	0.85 *	(0.06)	2.48 ***	(0.13)	2.31 ***	(0.10)	0.93	(0.06)
Black*Age:	23-24	1.00	--	1.00	--	1.00	--	1.00	--	1.00	--	1.00	--
	25-29	1.10 *	(0.04)	1.15 ***	(0.04)	1.05	(0.05)	1.05	(0.04)	1.01	(0.04)	0.96	(0.05)
	30-34	1.06	(0.05)	1.17 ***	(0.05)	1.10 ~	(0.06)	1.02	(0.04)	1.00	(0.04)	0.98	(0.06)
	35-39	1.03	(0.06)	1.11 *	(0.05)	1.08	(0.08)	0.99	(0.06)	1.01	(0.05)	1.02	(0.08)
	40+	1.00	(0.14)	0.99	(0.08)	0.99	(0.16)	0.95	(0.13)	0.94	(0.08)	0.98	(0.16)
Education	Less than HS							1.00	--	1.00	--	1.00	--
	Some College							0.74 ***	(0.01)	0.75 ***	(0.01)	1.01	(0.02)
	College+							0.58 ***	(0.01)	0.55 ***	(0.01)	0.95 ~	(0.02)
Black*Education:	Less than HS							1.00	--	1.00	--	1.00	--
	Some College							1.01	(0.03)	1.09 **	(0.03)	1.08	(0.05)
	College+							1.12 **	(0.04)	1.18 ***	(0.04)	1.05	(0.06)
Married								0.63 ***	(0.01)	0.77 ***	(0.01)	1.21 ***	(0.03)
Black*Married								1.11 **	(0.04)	1.08 *	(0.03)	0.97	(0.04)
Intercept		0.04 ***	(0.00)	0.05 ***	(0.00)	1.31 ***	(0.03)	0.07 ***	(0.00)	0.08 ***	(0.00)	1.10 **	(0.03)

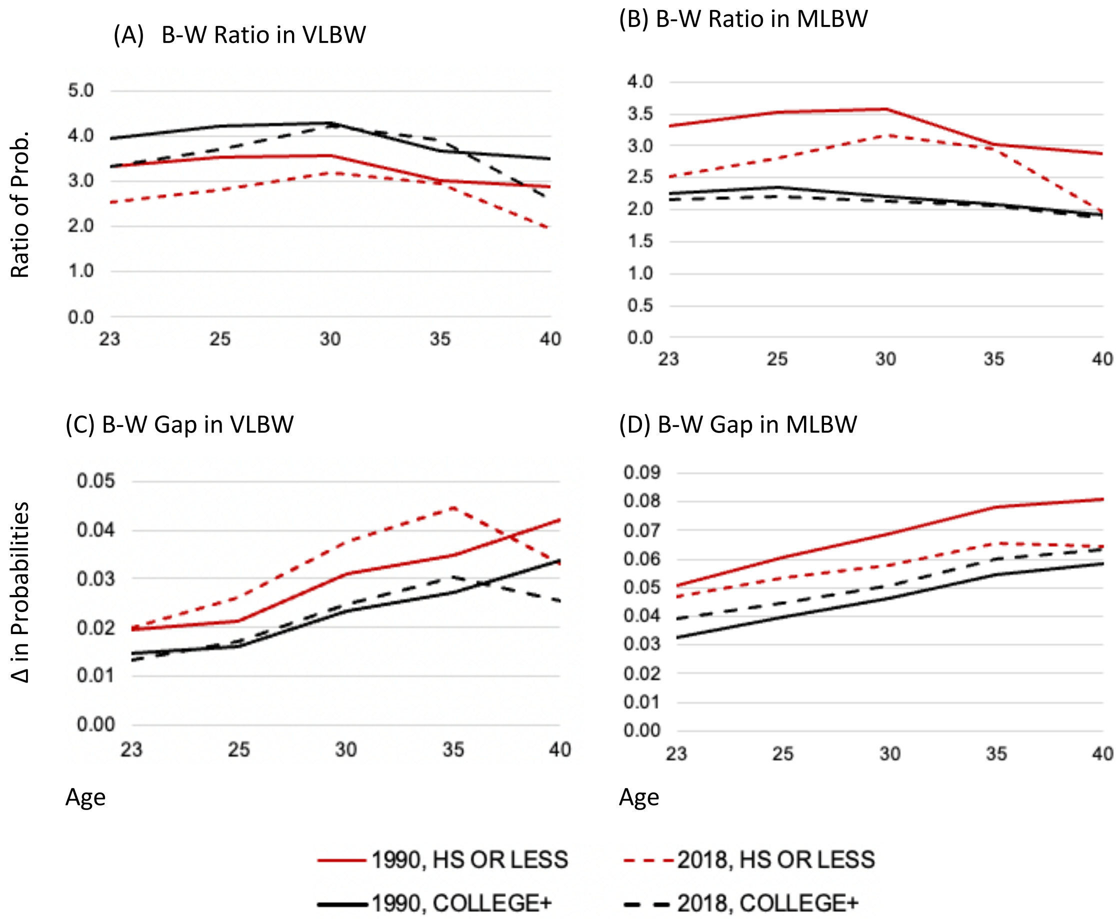
***p<0.001; **p<0.01; *p<0.05; ~p<0.10. [1]Stepwise multinomial logistic regression models that look at marital status and education separately are available in the appendix. [2] To simplify interpretation, these multinomial logistic regressions are stratified by year and the coefficients for change over time are drawn from separate models using the pooled 1990 and 2018 data that include two and three-way interactions with year.

FIGURE 1.2: Predicted Probabilities of Very Low and Moderately Low Birth Weight, by Race, Age, and Educational Attainment in 1990 & 2018



Notes: All predicted probabilities are generated using Stata 17 margins commands following the multivariate logistic regression. Probabilities by educational attainment used in these figures are not adjusted for marital status.

FIGURE 1.3: Black-White Ratios and Absolute Gaps in Predicted Probabilities of Very Low and Moderately Low Birth Weight, by Education, 1990 and 2018

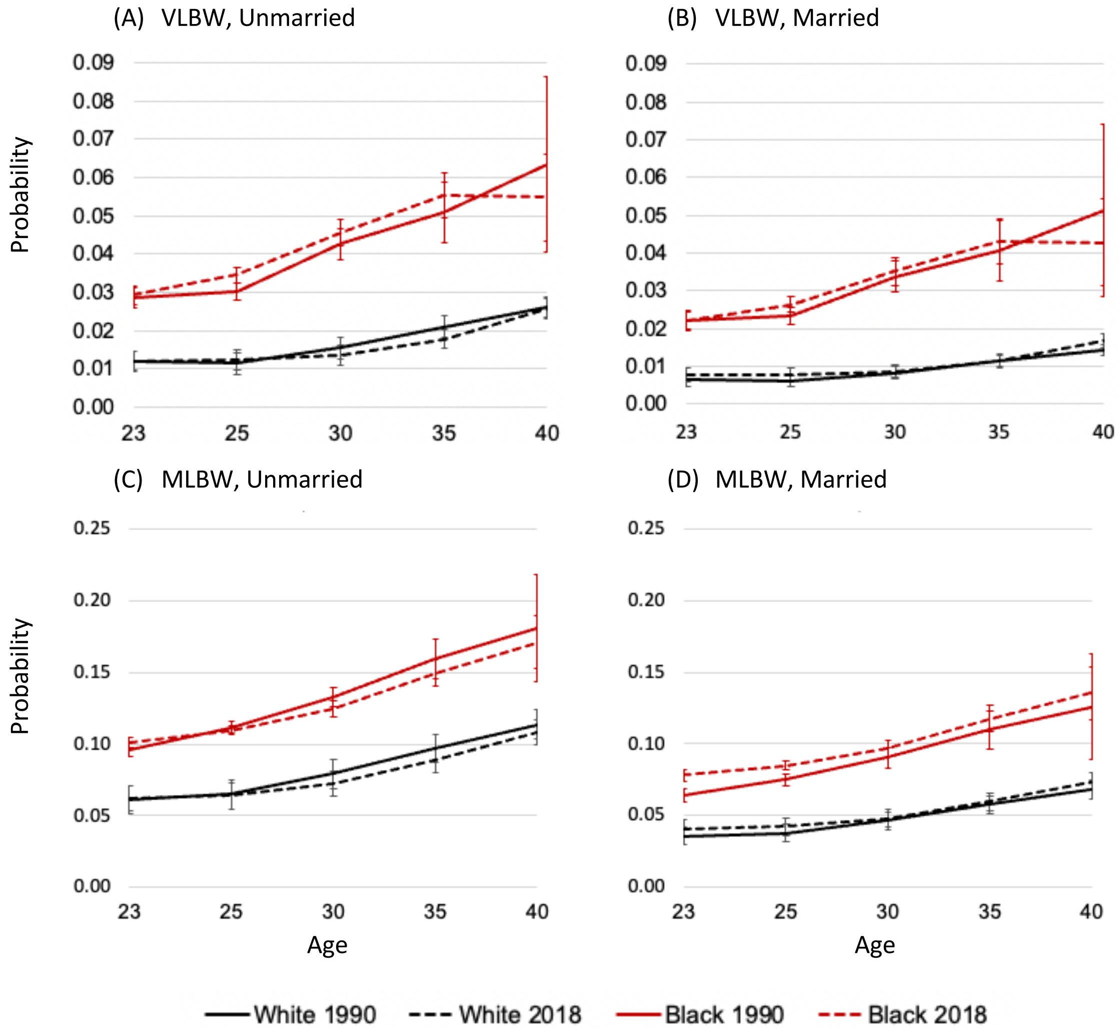


Panels A and B plot the ratio of Black to White predicted probability of very low (A) and moderately low (B) birth weight across maternal age.

Panels C and D plot the absolute difference in predicted probabilities by subtracting the White predicted probability from the Black predicted probability at each maternal age group for people with the same level of education.

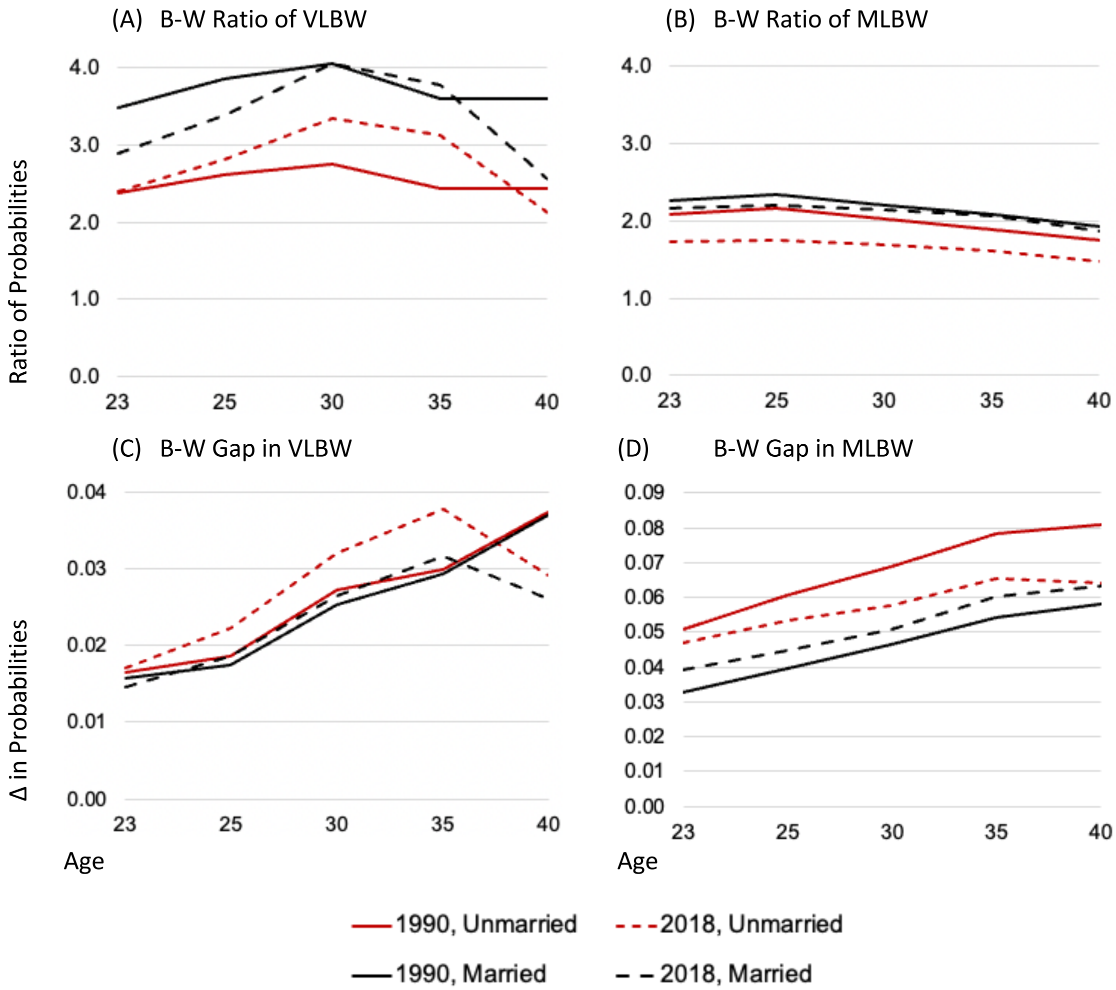
All predicted probabilities are generated using Stata 17 margins commands following the multivariate logistic regression. Probabilities by educational attainment used in these figures are not adjusted for marital status.

FIGURE 1.4: Predicted Probabilities of Very Low and Moderately Low Birth Weight, by Race, Age, and Marital Status, 1990 & 2018



Note: All predicted probabilities are generated using Stata 17 margins commands following the multivariate logistic regression. Probabilities by marital status used in these figures are not adjusted for educational attainment.

FIGURE 1.5: Black-White Ratio and Absolute Differences in Predicted Probabilities of Very Low and Moderately Low Birth Weight, by Age, Marital Status, and Year



Panels A and B plot the ratio of Black to White predicted probability of very low (A) and moderately low (B) birth weight across maternal age.

Panels C and D plot the absolute difference in predicted probabilities by subtracting the White predicted probability from the Black predicted probability at each maternal age group for people with the same level of education.

All predicted probabilities are generated using Stata 17 margins commands following the multivariate logistic regression. Probabilities by marital status used in these figures are not adjusted for educational attainment.

TABLE 1.3: Oaxaca Blinder Decomposition of Black-White gaps in Risk of Very Low and Moderately Low Birth Weight in 1990 vs. 2018[1] (N=1,252,634)

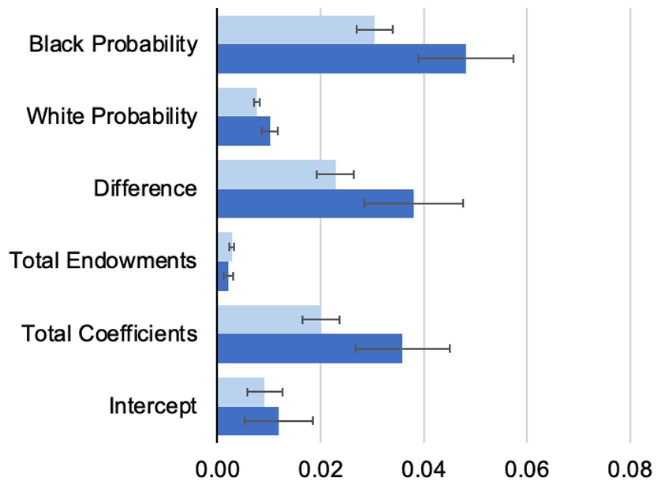
	1990			2018			Change in B-W Diff		
	% of Δ	Prob.	(se)	% of Δ	Prob.	(se)	% of Δ	ΔProb.	%Δ
VERY LOW BIRTH WEIGHT									
Adjusted Black Predicted Probability		0.030 ***	(0.001)		0.048 ***	(0.005)		0.018 ***	58%
Adjusted White Predicted Probability		0.008 ***	(0.000)		0.010 ***	(0.001)		0.003 ***	34%
Adjusted Difference	100%	0.023 ***	(0.001)	100%	0.038 ***	(0.005)	100%	0.015 ***	66%
Total Endowments	12%	0.003 ***	(0.000)	6%	0.002 ***	(0.000)	-4%	-0.001	-24%
Age	-3%	-0.001 ***	(0.000)	-3%	-0.001 ***	(0.000)	-3%	0.000 *	65%
Marriage	10%	0.002 ***	(0.000)	4%	0.002 ***	(0.000)	-6%	-0.001 *	-36%
College Grad	5%	0.001 ***	(0.000)	5%	0.002 ***	(0.000)	4%	0.001 ***	56%
Total Coefficients	88%	0.020 ***	(0.001)	94%	0.036 ***	(0.005)	104%	0.016 ***	79%
Age	31%	0.007	(0.000)	43%	0.017 ***	(0.004)	62%	0.009 *	132%
Marriage	12%	0.003 ***	(0.000)	2%	0.001 **	(0.000)	-14%	-0.002 ***	-77%
College Grad	4%	0.001	(0.001)	18%	0.007 **	(0.002)	39%	0.006	614%
Intercept	40%	0.009 ***	(0.002)	31%	0.012 ***	(0.003)	18%	0.003 *	29%
MODERATELY LOW BIRTH WEIGHT									
Adjusted Black Predicted Probability		0.105 ***	(0.001)		0.120 ***	(0.004)		0.015 **	14%
Adjusted White Predicted Probability		0.045 ***	(0.001)		0.052 ***	(0.001)		0.007 ***	15%
Adjusted Difference	100%	0.060 ***	(0.001)	100%	0.068 ***	(0.004)	100%	0.008	14%
Total Endowments	18%	0.011 ***	(0.000)	20%	0.013 ***	(0.000)	33%	0.003 ***	25%
Age	-6%	-0.004 ***	(0.000)	-6%	-0.004 ***	(0.000)	-5%	0.000 *	12%
Marriage	16%	0.010 ***	(0.000)	11%	0.008 ***	(0.000)	-23%	-0.002 **	-20%
College Grad	8%	0.005 ***	(0.000)	14%	0.010 ***	(0.001)	61%	0.005 ***	109%
Total Coefficients	82%	0.049 ***	(0.001)	80%	0.055 ***	(0.004)	67%	0.006	11%
Age	14%	0.008	(0.001)	1%	0.000	(0.004)	-93%	-0.008 *	-95%
Marriage	4%	0.003 ***	(0.001)	3%	0.002 ***	(0.000)	-10%	-0.001	-33%
College Grad	7%	0.004 *	(0.001)	9%	0.006	(0.003)	25%	0.002	49%
Intercept	57%	0.034 ***	(0.001)	68%	0.046 ***	(0.004)	146%	0.012 **	35%

***p<0.001; **p<0.01;*p<0.05; ~p<0.10

[1] Kitagawa-Oaxaca-Blinder decompositions of Black-White gaps in probability of very low birth weight and moderately low birth weight are run separately in 1990 and 2018. P-values for the change over time are derived from non-parametric bootstrap estimation of the 1990 and 2018 decompositions combined. Wald tests are used to assess statistical significance of the change in the explanatory variables~ endowments and coefficients of the Black-White gap over time.

FIGURE 1.6: Oaxaca-Blinder Decomposition of Black-White Gaps in Probability of Very Low Birth Weight (<1,500 grams) in 1990 and 2018

(A) Summary



(B) Detailed Decomposition

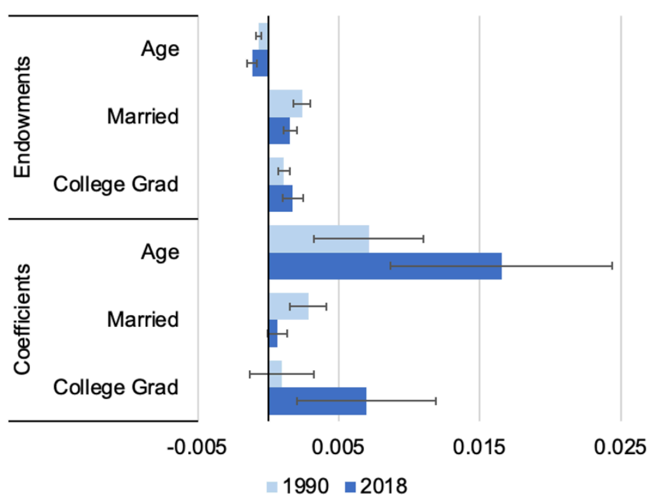


Figure 1.6A-B displays the results of the Kitagawa-Oaxaca-Blinder decomposition detailed in Table 1.3. The results identify the portion of the Black-White gap in probability of very low birth weight (less than 1,500 grams) in 1990 and 2018 that is attributable to racial differences in the distribution of characteristics (i.e., endowments) and racial differences in the association between those characteristics and risk of very low birth weight (i.e., coefficients).

Panel A provides the summary of the total gap and that which is attributable to the endowments and coefficients of all characteristics combined and that which is attributable to group membership (i.e., group-specific intercepts).

Panel B provides the detailed decomposition of the gap that is attributable to racial differences in the endowments and coefficients of age, marital status, and college educational attainment. All results are generated using Stata 17 and the oaxaca command.

FIGURE 1.7: Oaxaca-Blinder Decomposition of Black-White Gap in Probability of Moderately Low Birth Weight (1,500-2,499 grams) in 1990 and 2018

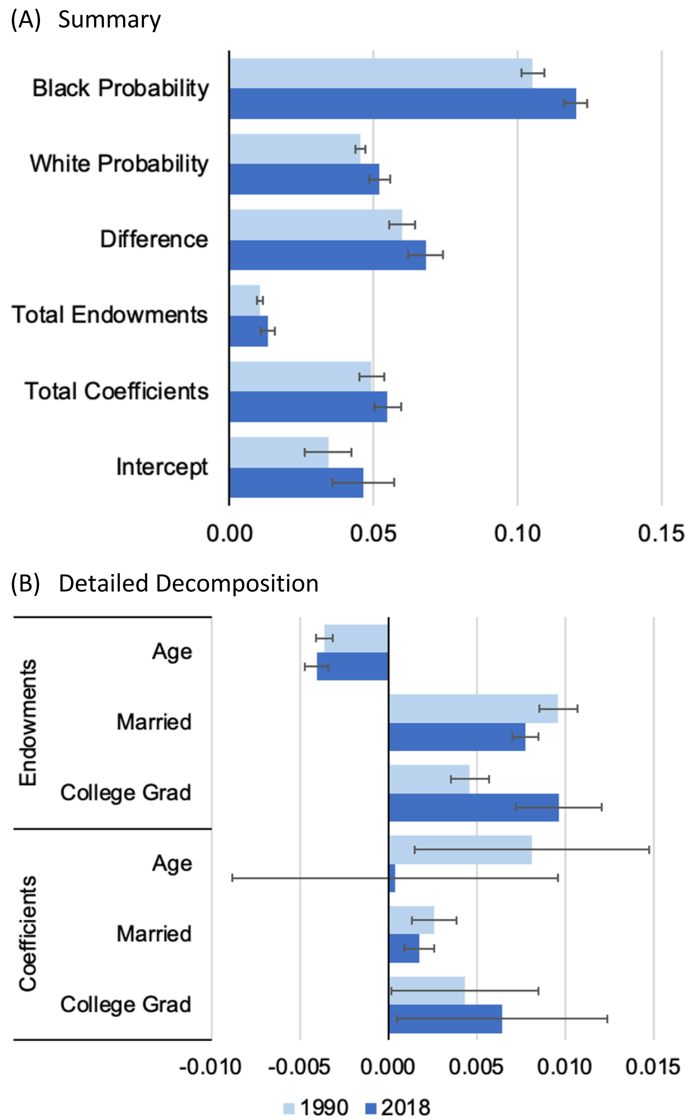


Figure 1.7A-B displays the results of the Kitagawa-Oaxaca-Blinder decomposition detailed in Table 1.3. The results identify the portion of the Black-White gap in probability of moderately low birth weight (1,500-2,499 grams) in 1990 and 2018 that is attributable to racial differences in the distribution of characteristics (i.e., endowments) and racial differences in the association between those characteristics and risk of moderately low birth weight (i.e., coefficients).

Panel A provides the summary of the total gap and that which is attributable to the endowments and coefficients of all characteristics combined and that which is attributable to group membership (i.e., group-specific intercepts).

Panel B provides the detailed decomposition of the gap that is attributable to racial differences in the endowments and coefficients of age, marital status, and college educational attainment. All results are generated using Stata 17 and the oaxaca command.

CHAPTER 2: THE ROLE OF CHANGING OBSTETRIC PRACTICES IN RESHAPING BLACK AND WHITE BIRTH WEIGHT DISTRIBUTIONS AMONG LOW-RISK BIRTHS

Abstract

Throughout the 1990s and 2000s, average birth weight has been on the decline and pre-term birth rates have increased. Much attention has been given to investigating the drivers behind shifts in birth weight and gestational age, looking to changing demographics, health behaviors, and obstetric practices. However, existing research has failed to fully explain these shifts and the racial patterning of these changes over time using standard regression techniques. The current study uses classic demographic methods to investigate how race-specific changes to the probability of birth and obstetric intervention at each gestational age has contributed to changes in mean gestational length for low-risk births between 1990 and 2018 within and across racial groups. Along with a rapid expansion in the use of labor induction and cesarean section in recent decades, there has been growing concern about a rise in obstetric intervention on low-risk pregnancies that may not have required intervention if allowed to progress naturally. Thus, this study exclusively investigates the role of obstetric intervention on reshaping the gestational age distribution of low-risk births over time and across race. By focusing only on low-risk births, this study removes the potentially confounding effect of racial gaps in health-related risk factors that may have shifted over time to

hone in on patient and provider decisions regarding obstetric intervention that occur, at least in part, independently of recorded health risk factors.

Life table analyses reveal a substantial decrease in gestational length for low-risk White births and a slight increase in gestational length for low-risk Black births. I find that for White births, the entirety of the decrease in gestational length is attributable to increases in gestational-age specific rates of labor induction and cesarean section. Increased labor inductions and cesarean sections contribute a similar shortening of the expected gestational length for Black births, but this shortening is offset by simultaneous decreases in the probability of birth without obstetric intervention at earlier gestational ages, when birth weights are lowest, and risk of adverse outcomes is highest.

Introduction

Background

Throughout the 1990s and 2000s, average birth weight has been on the decline and pre-term birth rates have increased (Martin et al. 2018). Much attention has been given to investigating the drivers behind the birth weight decline, looking to changing demographics, health behaviors, and obstetric practices, with mixed results. At the same time, the cesarean delivery rate has also increased steadily in the United States (Getahun et al. 2009; Martin et al. 2018; Tilstra and Masters 2020a) and the probabilities of birth from labor induction and cesarean section have increased across all gestational ages (Tilstra and Masters 2020). In 2018, 32% of all births and 22% of births to people with no history of prior cesarean were delivered via cesarean section (Martin 2019).

Cesarean section can be an essential life-saving medical procedure for both birthing people and neonates who are at risk of serious intrapartum birth complications. However, cesarean delivery itself is also associated with substantial risk of morbidity for the birthing person. In the short-term these include wound infections or hematomas, post operative febrile illness, urinary and bladder infections following catheterization, anesthesia-related complications, and surgical complications including hemorrhage requiring transfusion or hysterectomy, bowel or bladder injury, thromboembolic disease (i.e., the formation and dislodging of venous blood clots), and maternal death (Gregory et al. 2012). Of the top ten leading causes of intrapartum death in the United States, six are more common among cesarean deliveries compared to vaginal deliveries (Gregory et al. 2012; Petersen et al. 2019). In the long term, previous cesarean may also be associated with subsequent infecundity and higher risks of future pregnancy complications, including uterine rupture, ectopic pregnancy, miscarriage, and abnormal placentation (e.g., placental abruption and previa) (Hemminki 1996; Oral and Elter 2007; Silver 2010).

Concerningly, the expansion of cesarean rates over the past several decades have not been accompanied by marked improvements in morbidity and mortality, suggesting they may be overused. This has led to widespread calls for a reduction in low-risk cesareans from national and international public health and medical professional associations (American College of Obstetricians and Gynecologists (College) et al. 2014; Main 2017). Cesarean deliveries of singleton first births occurring at term for a fetus presenting head-first/non-breech are considered low-risk cesarean (LRC) deliveries in that they are less likely to be medically indicated (Vadnais et al. 2017). The LRC rate increased by 50% between 1997 and 2009 and then declined slightly between 2009 and 2013, along with declines in the overall cesarean delivery rate (Martin et al. 2018).

High LRC rates mean that more birthing people may be unnecessarily exposed to the risks associated with cesarean section. These procedures also contribute to rising health care costs. In 2008, the WHO estimated that unnecessary C-sections in the United States cost nearly 700 billion dollars per year – over twice the amount of the next highest spender, China, at 326 billion USD (Gibbons et al. 2010). The American College of Obstetrics and Gynecology (ACOG) has made efforts to reduce LRC rates, by discouraging nonmedically-indicated cesarean delivery and induction of labor (ACOG 2014).

Despite these efforts, LRC rates remain high, particularly among people of color and those with lower individual and community-level socioeconomic resources (Tilstra 2018). LRC rates are consistently highest among non-Hispanic Black people, among whom rates have also been slower to decline since 2009 (Osterman and Martin 2014). These trends raise concern around the treatment and autonomy of vulnerable people during pregnancy and childbirth and the implications this has for disparities in birth outcomes and subsequent life course health. The extant literature has documented widespread differences in access to care and treatment by the medical system along racial and socioeconomic lines, with people of color being more likely to receive dismissive and/or coercive treatment from their providers. Consequently, Black birthing people are more likely to experience a coerced or forced cesarean section than their White counterparts (Bridges 2011; Morris and Robinson 2017; Murthy et al. 2007).

While cesarean delivery rates were on the rise, labor inductions also increased dramatically in the United States, more than doubling across all gestational ages between 1990 and 2010 and plateauing or declining slightly in the years since (Osterman 2014). The increase in labor inductions has been linked to the reduction in mean birth weight and increase in pre-term birth rates observed throughout the 1990s and 2000s, with obstetric intervention becoming relatively common during the late pre-term (34-36 weeks) and early term (37-38 weeks) stages of pregnancy (MacDorman et al. 2022, 2010; Murthy et al. 2011). Reported patterns of and reasons for this increase in labor induction are varied. Existing research suggests that while elective labor inductions at term are highest among White births, inductions during the late pre-term period (34-36 weeks of gestation), when the neonate is less developed, is most common among non-Hispanic Black births (Murthy et al. 2011; Singh et al. 2018).

Despite much attention paid to the shifting trends in obstetric interventions over time, we still do not have a clear understanding of the direct and indirect effects these changes have on average gestational length and how these patterns vary by race. Previous research has largely overlooked how large increases in the number of births that are delivered via obstetric intervention changes not only the distribution of births by gestational age but also the composition of births at each subsequent gestational age. This is a gap in the literature that is well addressed with demographic methods, such as life table techniques and decomposition.

A recent study by Tilstra and Masters (2020) uses life-table techniques to account for changing trends in the likelihood that a birth reaches a certain gestational age and describes shifts in the timing of births that more fully explain population-level reductions in birth weight over time. Through a counterfactual analysis, the authors also find that, if not for the observed changes to obstetric practices, average US birth weight would have increased between 1990 and 2013.

Tilstra and Masters offer an improvement on existing evidence by considering not only mean birthweight by gestational age at different time points, but also the joint probability of gestational-age-specific birth and obstetric intervention. However, the authors do not investigate how these probabilities vary by race, and thus it remains unknown whether broad increases in obstetric intervention over the past 3 decades may have reshaped Black and White gestational age distributions differently for low-risk births. To address this gap, the current study investigates the degree to which changes in gestational-age specific probabilities of birth and obstetric intervention have contributed to overall gestational length for low-risk Black vs. low-risk White births over time.

Aim

Specifically, the current study aims to understand how shifts in gestational-age-specific probabilities of birth and obstetric intervention have contributed to changes in the expected length of gestation for low-risk births by race from 1990 to 2018. Low risk births are defined in the next section.

Data and Methods

Data and Sample

This study uses completed birth record data from the National Center for Health Statistics in 1990, which predates the largest shifts in obstetric intervention, and 2018, which postdates these shifts and represents the current state of gestational age and birth outcomes in the United States. Complete reporting on important risk factors for both obstetric intervention and preterm birth, such as hypertension and diabetes were not widely available prior to 1990. The study includes all singleton first births occurring between 21 and 44 weeks of gestation to US born non-Hispanic Black and non-Hispanic White birthing people in each year. To control for different levels of health risk between groups and across time and better assess the role of patient and provider decisions around obstetric intervention that occur independently of individual-level risk, I include only low-risk births. Any birth to a person with health conditions such as chronic or pregnancy-related hypertension or diabetes, and/or eclampsia were removed. I also removed births to people who had smoked tobacco during pregnancy or had not received prenatal care before the second trimester of pregnancy. Lastly, as breech presentation is associated with nearly universal obstetric intervention, only vertex births were included in the life table analysis. Supplementary life-table analyses on the full sample of births are available in the appendix.

Observations that were missing information on birth weight, gestational age, maternal age, maternal Hispanicity, prenatal smoking, chronic hypertension, pregnancy related hypertension, diabetes, eclampsia, fetal presentation (i.e., breech, cephalic, etc) and month of first prenatal care visit were excluded from the analysis. I also exclude a small number of births with implausible birth weight for gestational age, defined as a birth weight that is more than 5 standard deviations away from the gestational age specific median birth weight. The final analytic sample for this analysis was 871,603 births, of which 456,137 were born in 1990 and 415,466 were born in 2018. The racial distribution of births in this sample were similar across years, at 15% Black in 1990 and 16% black in 2018. Table A2.1 in the appendix provides a summary of excluded observations.

Measures

The dependent variable is gestational age at birth, which begins with the first day of the last menstrual period (LMP) and ends with the day of birth. Beginning in 2014, the NCHS transitioned to using the clinical/obstetric estimate of gestational age of the newborn in its published reports and calculations. However, while LMP-based estimates were still reported in the vital records following this transition, national data based on the obstetric estimate were not available until 2007. Thus, this paper uses the LMP-based estimate in both time periods to assess change in average gestational length between 1990 and 2018.

Stratifying variables used in the life table analyses include year of delivery (1990 or 2018), maternal race (non-Hispanic White or non-Hispanic Black), and method of delivery. Delivery method is categorized into three groups: vaginal delivery following spontaneous onset of labor (i.e., no labor induction), delivery following chemical or surgical induction of labor (delivered either vaginally or via cesarean section) and delivery via cesarean section, with no induction of labor. This analysis is primarily concerned with how decisions on the part of individuals and providers have contributed to changes in gestational length over time. Combining all induced deliveries into one category was appropriate in this case, as the gestational age at birth for an induced labor will not change substantially if that birth is subsequently delivered vaginally versus via cesarean section. Thus, when there is any obstetric intervention, this analysis focuses on the initial intervention, either induction of labor or cesarean section.

Methods

This paper uses Arriaga's method (Arriaga 1984) to decompose the contributions of change in GA-specific probabilities of birth and obstetric intervention to the overall change in expected gestational length between 1990 and 2018, by race. These decompositions reveal how much of the change in overall gestational length is attributable to changes in 1) the probability of birth at each GA (i.e., the direct effect) and 2) the indirect effect of changes to the number of surviving pregnancies that are then exposed to the probability of birth at subsequent GAs. The contribution of each GA interval is then further decomposed into the proportion that is due to differences/changes in the GA-specific probabilities of birth with no obstetric intervention, births from labor induction, or births via cesarean section.

Race and year-stratified life tables include only eventual live births that have reached at least 21 weeks of gestation and are thus missing any live births prior to 21 weeks as well as any stillbirths or miscarriages. The expected remaining length of gestation is evaluated at gestational age 21 and thus the number of surviving pregnancies at 21 weeks (l_{21}) is treated as the radix of the life table. Equation 2.1 measures the contribution of differences in the probability of birth, by any method, in gestational age group x to x+n to differences in total expected length of gestation. The radix (l_0) refers to the total number of pregnancies observed at the earliest gestational age in the analysis, which is gestational age 21. Similarly, lx refers to the remaining “surviving” pregnancies at the beginning of each gestational age interval x. The notation ${}_nL_x$ refers to number of pregnancy days lived in the gestational age interval x to x+n and T_x refers to the total number of pregnancy days lived above gestational age x.

Equation 2.3 measures the contribution of differences in delivery rates by method i between gestational age x to x+n. The notation ${}_nR_x^i$ refers to the proportion of births occurring in gestational age interval x to x+n that are delivered via method i. The notation ${}_nm_x(1)$ refers to the overall delivery rate between gestational ages x to x+n among group 1 (either White or 1990, depending on the corresponding stratifying variable being race or year) and ${}_nm_x(2)$ refers to the same for group 2 (either Black or 2018). All equations were drawn from Preston, Heuveline, and Guillot (Preston, Heuveline, and Guillot 2000).

${}_{n}\Delta_{x}$ = Contribution of differences in the probability of birth, by any method, in gestational age group x to x+n to differences in total expected length of gestation.

$$ {}_{n}\Delta_{x} = \overbrace{\frac{l_x^{(1)}}{l_0^{(1)}} \cdot \left(\frac{{}_{n}L_x^{(2)}}{l_x^{(2)}} - \frac{{}_{n}L_x^{(1)}}{l_x^{(1)}} \right)}^{\text{Direct Effect}} + \overbrace{\frac{T_{x+n}^{(2)}}{l_0^{(1)}} \cdot \left(\frac{l_x^{(1)}}{l_x^{(2)}} - \frac{l_{x+n}^{1}}{l_{x+n}^{2}} \right)}^{\text{Indirect Effect}} \quad \textbf{(2.1)} $$

$$ {}_{\infty}\Delta_{x} = \frac{l_x^{(1)}}{l_0^{(1)}} \cdot \left(\frac{T_x^{(2)}}{l_x^{(2)}} - \frac{T_x^{(1)}}{l_x^{(1)}} \right) \quad \textbf{(2.2)} $$

$$ {}_{n}\Delta_{x} = \sum {}_{n}\Delta_{x}^{i} $$

${}_{n}\Delta_{x}^{i}$ = Contribution of differences in delivery rates by method i between gestational age x to x+n

$$ {}_{n}\Delta_{x}^{i} = {}_{n}\Delta_{x} \cdot \left(\frac{{}_{n}R_x^{i(2)} \cdot {}_{n}m_x^{(2)} - {}_{n}R_x^{i(1)} \cdot {}_{n}m_x^{(1)}}{{}_{n}m_x^{(2)} - {}_{n}m_x^{(1)}} \right), $$

$$ \text{where } {}_{n}m_{x} = \frac{{}_{n}d_{x}}{{}_{n}L_{x}} \text{ and } R_x^{i} = \frac{{}_{n}D_x^{i}}{{}_{n}D_{x}} \quad \textbf{(2.3)} $$

Results

Table 2.1a describes the distribution of maternal age, gestational age, and birth weight of the analytic sample of low-risk births by delivery method, year, and race. In 1990, 12% of White births and 8% of Black live birth deliveries were medically induced. By 2018, around one-third of both Black and White births were medically induced. In 1990, 31% of White births and 22% of Black births occurred late or post term (41+ weeks of gestation), but by 2018, only 20% of White births and 14% of Black births occurred late or post term. In both time periods, more Black births were born pre-term, but that gap narrowed between 1990 and 2018. Over the period, Black pre-term birth rates decreased from 13.7% to 9.6% while White pre-term birth rates decreased by a lesser amount from 6.5% to 5.8%.

Figure 2.1 describes changes to the distribution of births by gestational week between 1990 and 2018, by race. The largest shift occurs at gestational week 39, with both White and Black births being much more likely to be born early term (37-39 weeks) in 2018 than in 1990 and, consequently, much less likely to be born at or after 41 weeks of gestation, particularly for White births. Black pre-term (<37 weeks) births decreased between 1990 and 2018, with the largest decrease observed among early pre-term births (<34 weeks). However, Figure 2.2, which depicts the gestational-age specific rate of birth at each pre-term gestational week, by race and year, shows that the rate of pre-term birth for Black births remained higher than that for White births in both time periods.

Figure 2.3 displays the joint probability of birth and obstetric intervention across gestational weeks 33-42 (21-32 removed for legibility) for all births, by year. Births from labor inductions increased drastically in this time period. In 1990, the joint probability of birth and cesarean section was lower than the joint probability of birth and labor induction until 42+ weeks of gestation when the probabilities converge. However, the joint probability of birth and labor induction increased four and five-fold between 1990 and 2018 at 39 and 40 weeks of gestation, respectively. By 2018, the probability of birth from labor induction exceeds the probability of birth via cesarean section at every gestational week and is about two times higher than the probability of cesarean for births at term.

Contribution of obstetric interventions to race gaps in gestational length

Table 2.2a describes the cause decomposition of racial differences in GA and delivery-method-specific birth rates to the overall racial gap in average GA at birth in 1990 and 2018. In 1990, the average gestational length for Black births was 0.78 weeks (~5.5 days) shorter than for White births. At that time, racial differences in GA-specific rates of births with no intervention contributed 80% of the racial gap in expected gestational length. Racial differences in the GA-specific rates of births by cesarean contributed 23% of the racial gap in gestational length at that time, suggesting that if Black birthing people were exposed to the same GA-specific rates of cesarean delivery as whites, the Black-White gap in gestational length would have narrowed by 23% or 0.17 weeks. Inductions contributed only -2% to the racial gap. A negative contribution suggests that if Black birthing people had been exposed to the same GA-specific induction rates, the racial gap in gestational length would be slightly wider.

By 2018, the racial gap in expected gestational length had narrowed to 0.48 weeks (~3.4 days) and racial differences in GA-specific rates of births with no intervention contributed about half of the total gap, with racial differences in GA-specific rates of births from induction now contributing 13% and cesareans contributing 35%. Notably, as Black pre-term births decline and race differences in GA-specific probabilities of birth with no intervention narrow at the earlier GAs, the increases in inductions and cesareans after 36 weeks of gestation contribute a larger share of the total gap in gestational length between Black and White births in 2018, even as the gap narrows over time.

Contribution of obstetric interventions to change in gestational length within race

Table 2.2b decomposes the change in gestational length over time within race, indicating that the narrowing of the racial gap seen in Table 2.2a has emerged primarily due to a greater decrease in average gestational length over time for White births (-0.26 weeks) and, to a lesser degree, gains in average gestational length among Black births (+0.04 weeks). While changes to GA-specific probabilities of birth by induction and cesarean contributed similarly to a shortening of the average gestational length for Black and White births, for Black births, this was offset by changes to the GA-specific probabilities of birth with no obstetric intervention. Therefore, average gestational length remained largely unchanged for Black births while decreasing for White births.

Contribution of differences in the probability of obstetric intervention at each GA to differences in total gestational length

Figure 2.4, panels A and B provide a more detailed depiction of the contribution of racial gaps in delivery-method- and GA-specific probabilities of birth to the total racial gap in average gestational length in 1990 (Panel A) and 2018 (Panel B). Meanwhile, panels C and D break down changes in average gestational length over time, within race. Values above the X-axis signal a positive contribution to average gestational length.

Notably in Panel D, the decrease in Black pre-term births and thus lower GA-specific probability of birth earlier in pregnancy has both a direct and indirect effect on overall gestational length that is positive. Conversely, earlier obstetric intervention on births that may have otherwise been carried longer has a shortening effect on overall gestational length and will appear below the X-axis.

In 1990 (Panel A), GA-specific probabilities of birth with no intervention and via cesarean section contributed to a shorter overall gestational length for Black births compared to White births across nearly all GAs. Racial differences in GA-specific probabilities of birth from labor induction narrowed the racial gap in gestational length after 38 weeks of gestation. By 2018 (Panel B), the contribution of pre-term births (<37 weeks) to the overall racial gap in gestational lengths diminished while the contribution of term births was similar across time.

Figure 2.4, panels C and D break down race-specific changes in average gestational length between 1990 and 2018 for White births (C) and Black births (D) separately. Figure 2.4 panel D illustrates why pre-term births contribute less to the racial gap in gestational length over time, as decreases in the GA-specific probability of birth prior to 37 weeks contributes to higher average gestational lengths for Black births over time. Meanwhile, changes in the probability of White pre-term birth makes little contribution to changes in White gestational length between 1990 and 2018.

Changes to the GA-specific probabilities of labor induction contribute to a shortening of the total gestational length for both Black and White births over time, particularly among early-term (37-38 weeks) and full-term (39-40 weeks) births. Changing induction and cesarean rates contributed a greater decrease in average gestational length for Black births compared to White births prior to 39 weeks of gestation, after which shifts in inductions and cesareans contributed a slightly greater decrease in White gestational lengths.

Discussion

This study makes an important contribution to understanding the implications of changes to obstetric intervention on gestational length considering underlying shifts in the distribution of births by gestational age among births with no identified risk factors on the birth record. In the wake of increased cesarean and labor induction rates, previous research had failed to disentangle the role of elective or pre-emptive obstetric intervention decisions from other factors driving rates of pre-term birth and low birth weight. Life table techniques allow us to go beyond describing broad associations between obstetric intervention and pre-term birth over time. Instead, by accounting for the probability of birth and obstetric intervention at each gestational age that is conditional on a pregnancy surviving to that gestational age, we can quantify the degree to which changes in the GA-specific rates of obstetric intervention contributed, both directly and indirectly, to overall changes in the total length of gestation. As the timing and levels of obstetric intervention vary substantially by race, these analyses reveal important variations in patterns across time and between racial groups.

This study revealed vast increases in the probability of labor induction for both Black and White births, particularly between 36 and 39 weeks of gestation. Arriaga age and “cause” (i.e., type of delivery) decomposition of differences in expected gestational length between groups and across time reveal important differences and similarities in how the expansion in obstetric intervention influenced the timing of births by race. Results show a substantial decrease in gestational length for low-risk White births and a slight increase in gestational length for low-risk Black births. For the White births, the entirety of the decrease in gestational length was attributable to increases in GA-specific rates of labor induction and cesarean section. Increased labor inductions and cesarean sections contribute a similar shortening of the expected gestational length for low-risk Black births, but this shortening is offset by simultaneous decreases in the probability of birth without obstetric intervention at earlier GAs, when birth weights are lowest and risk of adverse outcomes is highest.

While obstetric intervention rates increased for all births over the period, higher rates of obstetric intervention among Black births, particularly those occurring late pre-term and early term, remain an important driver of racial differences in average gestational length. The reduced contribution of pre-term births to racial gaps in gestational length suggest that absent higher rates of obstetric intervention over time, low-risk Black pregnancies may have experienced a more substantial lengthening between 1990 and 2018, which may have resulted in improvements in mean birth weight for Black births over time.

Limitations

The current study has some limitations to the analysis that should be noted. Gestational age is measured in weeks, rather than days, and thus the assumption that decrements are evenly distributed throughout each gestational age interval in the multi-decrement life table may be threatened, particularly at later gestational ages when the force of decrement could be higher. Similar analyses utilizing more granular gestational age data, such as those from medical records, may improve precision in estimates of gestational length. However, this analysis has the benefit of population-level generalizability that hospital records may lack.

In using administrative records, the current study also lacks more in-depth information about the underlying social dynamics that may be driving individual-level risks of both obstetric intervention and preterm birth. Future analyses may explore the role that specific psychosocial and material resources play in the power dynamics and negotiations within obstetric care and their implications for the timing and characteristics of births, by race.

Lastly, while the focus on low-risk births reveals important shifts that have occurred largely independently of shifts in individual-level health risk factors, this analysis does not investigate the drivers of observed birth weight and gestational age shifts for all births over time and across race.

Conclusion

This study makes an important contribution to understanding the role of changing obstetric practices in reshaping the gestational age distribution and overall gestational length of Black vs. White pregnancies over the past 3 decades. The reduced contribution of pre-term births to racial gaps in gestational length suggest that absent higher rates of obstetric intervention over time, low-risk Black pregnancies may have experienced a more substantial lengthening between 1990 and 2018. However, lower rates of early preterm birth among low-risk Black pregnancies were offset by increased obstetric interventions in the late preterm and early term period (34-38 weeks).

While vast increases in obstetric intervention rates over time have contributed to a similar shortening of gestational lengths for both groups, these interventions have contributed more strongly to low-risk Black pregnancies prior to 39 weeks of gestation. Meanwhile, low-risk White pregnancies are less likely to receive an obstetric intervention prior to reaching full term. This racial divide in the timing of interventions may have important implications for racial gaps in both birth weight and maternal health risks.

Cesarean section is associated with higher rates of postpartum morbidity and mortality than vaginal delivery (Gregory et al. 2012; Petersen et al. 2019) and Black birthing people already bear a disproportionate burden of severe maternal morbidity and mortality compared to White birthing people (Creanga, Bateman, et al. 2014; Creanga, Berg, et al. 2014; Tangel et al. 2019). Thus, it is important that hospital policies as well as medical training support individualized assessments of risk that do not essentialize race when making decisions regarding obstetric intervention.

Chapter 2 Tables and Figures

Note: All tables and figures include only low-risk first singleton births to US-born non-Hispanic White and non-Hispanic Black people between the age of 15-49 who delivered in a health facility in 1990 or 2018. Low-risk births are defined as live births born to non-smoking people with no history of chronic or gestational hypertension or diabetes and no eclampsia diagnosis. Birthing people must have received prenatal care within the first trimester of pregnancy. Lastly, the infant must have presented in a vertex/cephalic position during labor. This sample includes 871,603 low risk births, including 733,621 White births and 137,982 Black births. Some key analyses on the full sample (N=1,684,114) are available in the appendix.

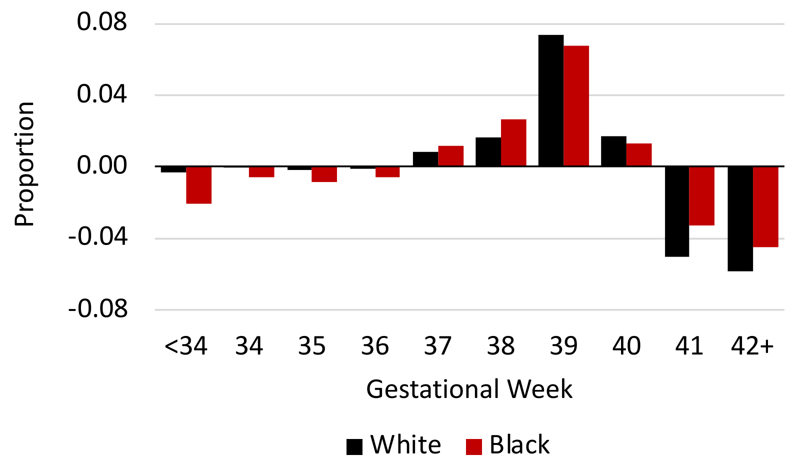
TAI

Delivery method[2]	1990 SV	1990 IND	1990 CES	1990 Total	2018 SV	2018 IND	2018 CES	2018 Total	Change (2018-1990)[3] SV	Change IND	Change CES	Change Total
	%;μ(sd)	%;μ(sd)	%;μ(sd)	%;μ(sd)	%;μ(sd)	%;μ(sd)	%;μ(sd)	%;μ(sd)	Δ%pts;Δμ	Δ%pts;Δμ	Δ%pts;Δμ	Δ%pts;Δμ
White Births												
Maternal Age (yrs)	25.0	25.5	26.3	25.3	27.3	27.3	29.0	27.5	2.3 ***	1.8 ***	2.7 ***	2.2 ***
	(5)	(5)	(5.2)	(5)	(5.1)	(5.4)	(5.4)	(5.3)				
Birth Wgt (grams)	3,396	3,553	3,555	3,442	3,333	3,427	3,422	3,377	-63.4 ***	-126.9 ***	-133.6 ***	-65.5 ***
	(494.1)	(512.8)	(594.6)	(519.6)	(450.1)	(477.6)	(607)	(486.4)				
Gest. Age (weeks)	39.4	40.1	39.7	39.5	39.1	39.6	39.0	39.3	-0.3 ***	-0.5 ***	-0.7 ***	-0.3 ***
	(2.1)	(1.9)	(2.2)	(2.1)	(1.8)	(1.6)	(2.1)	(1.8)				
Gest. Age Category												
Early PT (21-33)	1.6	0.7	1.8	1.5	1.3	0.6	2.4	1.2	-0.3 ***	-0.1 *	0.6 ***	-0.3 ***
Late PT (34-36)	5.4	3.4	4.4	5.0	5.1	3.2	6.4	4.6	-0.3 ***	-0.2 *	2.0 ***	-0.4 ***
Early T (37-38)	17.3	12.2	13.6	16.1	21.2	14.0	19.7	18.6	3.9 ***	1.8 ***	6.1 ***	2.5 ***
Full T (39-40)	48.9	36.8	44.4	46.6	56.4	55.2	54.3	55.7	7.5 ***	18.5 ***	9.9 ***	9.1 ***
Late-Post T (41+)	26.8	47.0	35.8	30.8	16.1	27.0	17.2	19.9	-10.8 ***	-20.0 ***	-18.6 ***	-10.9 ***
Total N	273,436	48,016	64,670	386,122	181,371	117,318	48,810	347,499				
Total Row %	70.8	12.4	16.7	100.0	52.2	33.8	14.0	100.0	-18.6 ***	21.3 ***	-2.7 ***	
Black Births												
Maternal Age (yrs)	21.1	22.5	23.2	21.6	23.4	24.0	25.7	24.0	2.3 ***	1.5 ***	2.5 ***	2.4 ***
	(4.6)	(5)	(5.4)	(4.9)	(4.9)	(5.2)	(5.9)	(5.2)				
Birth Wgt (grams)	3,114	3,261	3,274	3,156	3,100	3,176	3,121	3,126	-13.1 ***	-84.9 ***	-153.5 ***	-29.7 ***
	(546.3)	(555.4)	(633.4)	(569.3)	(468.1)	(502.7)	(651.4)	(516.9)				
Gest. Age (weeks)	38.6	39.4	39.1	38.7	38.7	39.2	38.5	38.8	0.1 ***	-0.2 ***	-0.6 ***	0.0 **
	(2.9)	(2.6)	(2.8)	(2.8)	(2.1)	(1.9)	(2.5)	(2.1)				
Gest. Age Category												
Early PT (21-33)	4.9	2.9	4.1	4.6	2.4	1.2	4.9	2.5	-2.4 ***	-1.7 ***	0.9 ***	-2.1 ***
Late PT (34-36)	9.8	7.3	7.4	9.1	7.5	5.2	8.9	7.1	-2.3 ***	-2.1 ***	1.5 ***	-2.0 ***
Early Term (37-38)	23.1	17.8	18.0	21.7	28.7	20.8	23.8	25.5	5.6 ***	3.0 ***	5.9 ***	3.8 ***
Full Term (39-40)	43.0	37.2	42.9	42.5	49.8	53.2	48.7	50.6	6.8 ***	16.1 ***	5.9 ***	8.1 ***
Late-Post T. (41+)	19.2	34.8	27.7	22.1	11.6	19.6	13.6	14.3	-7.6 ***	-15.3 ***	-14.1 ***	-7.8 ***
Total N	51,034	5,375	13,606	70,015	35,736	19,949	12,282	67,967				
Total Row %	72.9	7.7	19.4	100.0	52.6	29.4	18.1	100.0	-20.3 ***	21.7 ***	-1.4 ***	

*** p<0.001; **p<0.01; *p<0.05

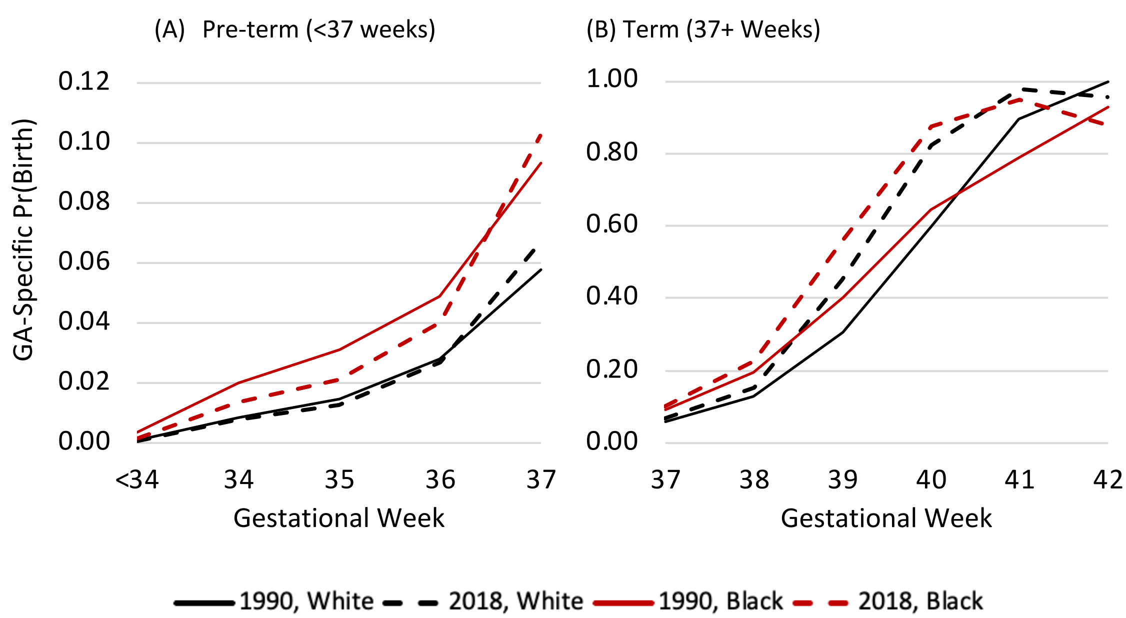
[1] Table 2.1a includes only low-risk births. The distribution of risk factors within the full sample are available in the appendix (see Table A2.2a and A2.2b). [2] SV = Spontaneous Vaginal delivery (i.e., no induction of labor); IND = Labor was either medically or surgically induced, delivery may have been vaginal or via cesarean; CES = Labor was not induced, delivery by cesarean section; [3] P-values are derived from t-tests for significant differences in year-specific means for continuous variables (age, birth weight, gestational age) and chi-square tests of proportions for gestational age category.

FIGURE 2.1 Change in the distribution of low-risk[1] births 2018-1990 by gestational age and race (N_{White} = 733,621; N_{Black} = 137,982)



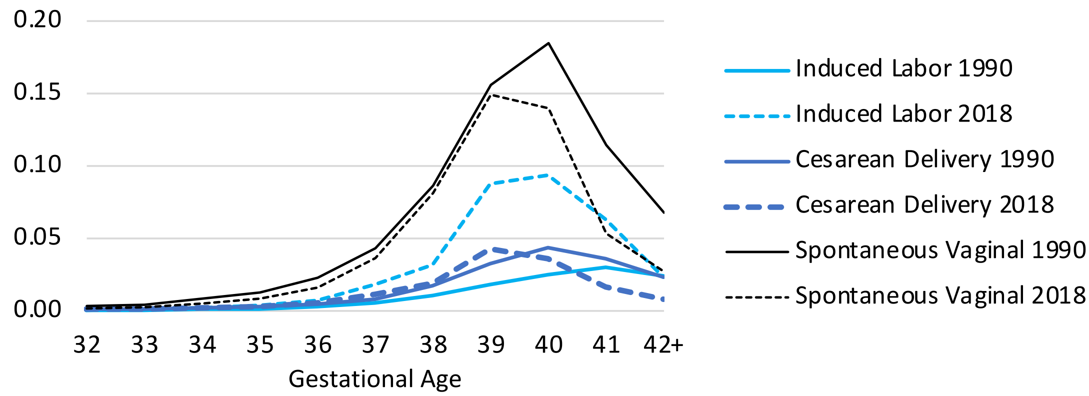
Notes: The change in the distribution of births is calculated as the proportion of total births occurring in gestational week x in 2018 minus the proportion of total births occurring in gestational week x in 1990. This calculation is made for White and Black births separately

FIGURE 2.2: Gestational-age-specific rate of birth, by length of gestation, among low-risk[1] pregnancies, by race and year (N_{White} = 733,621; N_{Black} = 137,982)



Notes: The gestational-age-specific birth rate (nmx) is calculated as the number of births occurring during gestational week x (ndx) divided by the number of pregnancy-weeks "lived" in the gestational age interval x to x+n (nLx).

FIGURE 2.3: Joint probability of birth and obstetric intervention for all low-risk[1] births, by year and delivery method (N=871,603)



Notes: The joint probability of birth and obstetric intervention is calculated by multiplying the proportion of births occurring in each gestational week by the proportion of births in that week that are born via each delivery method. Gestational weeks 21-31 are not shown in the figure to improve legibility.

TABLE 2.2a: Contribution of **Black-White gap** in GA-specific rates of obstetric intervention to the total gap in expected gestational length among low-risk births, by year

	1990		2018	
	Weeks	%	Weeks	%
White Mean Gest. Length	40.03		39.76	
Black Mean Gest. Length	39.25		39.29	
Black-White Gap ($\sum {}_n\Delta_x$)	-0.78	100%	-0.48	100%
Method Decomposition ($\sum {}_n\Delta_x^i$)				
Spontaneous	-0.62	80.0%	-0.25	52.2%
Inductions	+0.02	-2.4%	-0.06	13.4%
Cesareans	-0.17	22.5%	-0.16	34.5%

TABLE 2.2b: Contribution of **change** in GA-specific rates of obstetric intervention to the total change in expected gestational length among low-risk births between 1990 and 2018, by race

	White		Black	
	Weeks	%	Weeks	%
1990 Mean Gest. Length	40.03		39.25	
2018 Mean Gest. Length	39.78		39.29	
Black-White Gap ($\sum {}_n\Delta_x$)	-0.26	100%	0.04	100%
Method Decomposition ($\sum {}_n\Delta_x^i$)				
Spontaneous	0.17	-67%	0.46	1249%
Inductions	-0.41	160%	-0.39	-1072%
Cesareans	-0.02	7%	-0.03	-77%

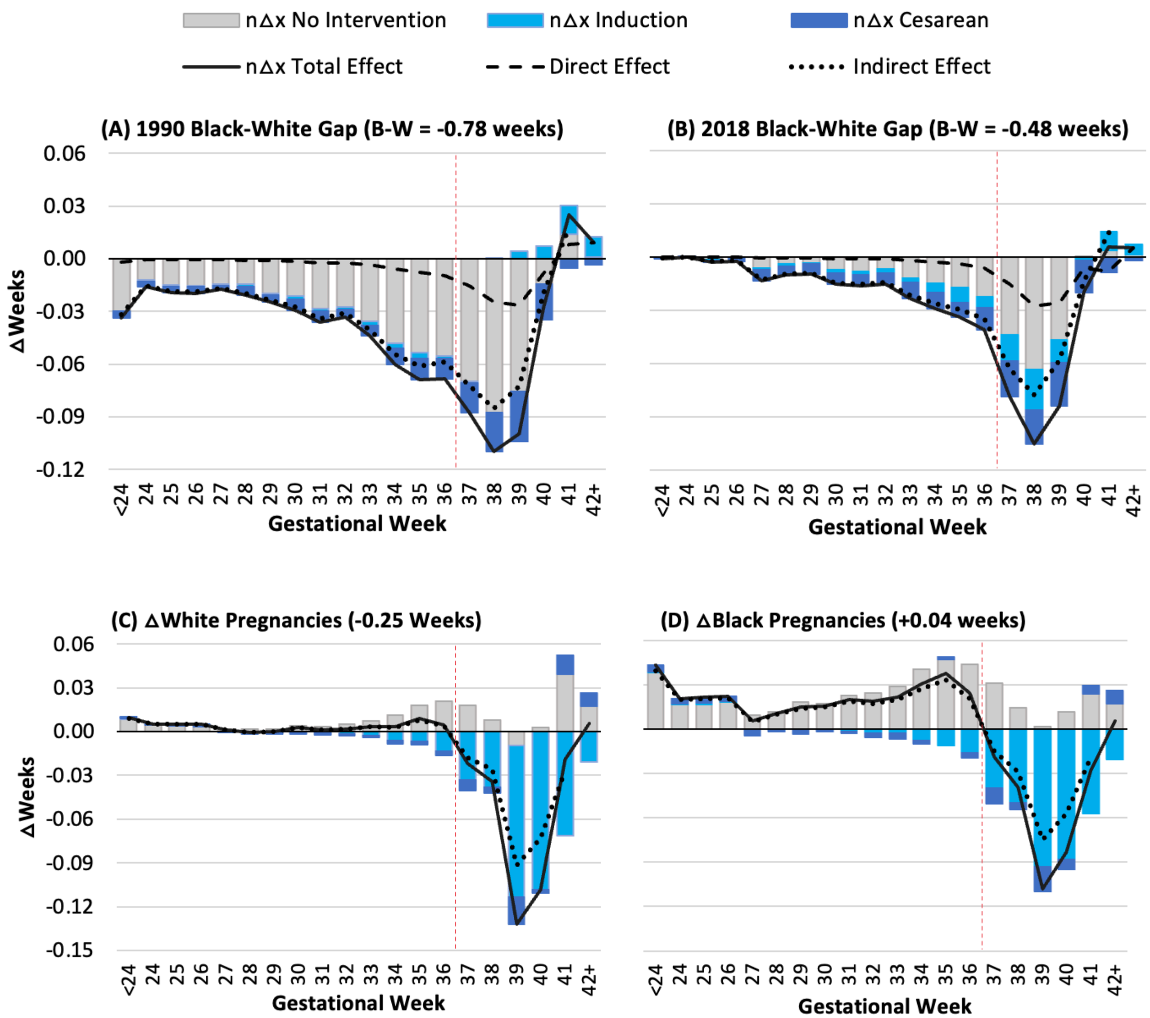
Notes: Average gestational length was calculated using multi-decrement life tables to estimate the expected remaining length of gestation among all low-risk pregnancies that reached GA=21 (e_{21}). Gestational expectancy is calculated by dividing the total number of pregnancy-weeks "lived" between GA 21-44 (T_{21}) by the total number of pregnancies that resulted in a live birth between GA 21-44 (l_{21}). The table above displays the total gestational length conditional on reaching GA=21 (e_{21} + 21) for ease of interpretation.

Method decomposition describes the contribution of racial differences in GA- and delivery-method specific birth rates to the overall racial gap in average gestational length in each year. This is calculated with equations 2.1-2.3 and summed across all gestational age intervals.

${}_n\Delta_x$ = Contribution of differences in the probability of birth, by any method, in gestational age group x to x+n to differences in total expected length of gestation.

${}_n\Delta_x^i$ = Contribution of differences in delivery rates by method i between gestational age x to x+n

FIGURE 2.4: Arriaga gestational age and delivery method decomposition of differences in gestational length among low-risk births[1] (N=871,603)



Note: The above graphs depict the gestational age specific contribution made by differences in the probabilities of birth and obstetric intervention at each GA to either a lengthening (above the x-axis) or shortening (below the x-axis) of the total average gestational length between races in each time point (Panels A & B) and over time within race (panels C & D). Columns to the left of the vertical red line between gestational age 36 and 37 are considered pre-term (<37 weeks) and those to the right of the vertical red line are considered term pregnancies or later.

The direct effect refers to the difference in gestational length that is attributable to differences in the probability of birth at each gestational age while the indirect effect refers to the difference in gestational length that is attributable to changes to the number of surviving pregnancies at each gestational age.

1Figure 2.4 includes only low-risk births. Identical analyses on the full sample of 1,684,114 births is available in the appendix (see Figure A2.4)

CHAPTER 3: THE ROLE OF RACIALIZED FELONY DISENFRANCHISEMENT ON RACIAL DISPARITIES IN RISK OF LOW BIRTH WEIGHT AND HYPERTENSION

Abstract

Felony disenfranchisement in 2016 resulted in the removal of six million voters from the rolls, the majority of whom had fully completed serving their sentences and were living in their communities with no civic right to vote in democratic elections. Given vast racial disparities in risk of arrest, conviction, and incarceration, the impacts of felony disenfranchisement are felt disproportionately by Black communities. This paper seeks to understand the role of this institutional process of racialized political exclusion in shaping birth weight risks for White vs. Black births exposed to different levels of racialized disenfranchisement.

I use multi-level mixed effects logistic regression of state-level racialized disenfranchisement on odds of low birth weight (<2,500 grams). I also investigate the same associations with odds of chronic hypertension among birthing people and find substantial increase in risk from exposure to racialized disenfranchisement. The strength of association with chronic hypertension suggests an emergence of risk prior to conception, which has important implications from a life course perspective. This study makes an important contribution to our understanding of the role of the criminal legal

system and racialized political exclusion on upholding existing power structures and shaping risks for marginalized groups.

Introduction

Background

The United States has some of the most restrictive felony disenfranchisement laws among modern democracies. Commission of a felony results in the immediate revocation of the right to vote in democratic elections in 48 American states. In 30 of those states, voting rights are not restored even after serving out one's sentence (See Figure 3.1 for a summary of state-level restrictions). In 2016, only 23% of the disenfranchised population was currently incarcerated and 51% had fully completed serving their sentences. The remaining 26% were being supervised outside of prison or jail through the probation or parole system (Uggen, Larson, and Shannon 2016). Inequities in the life-time risk of felony conviction and incarceration mean that felony disenfranchisement disproportionately dilutes the voting strength of racially minoritized populations.

Most of these policies originated in the 1860s and 1880s in reaction to the passage of the 14th amendment, which extended equal protection and suffrage to formerly enslaved Black men (Pettus 2004). Felony disenfranchisement provided a "race-neutral" means of maintaining existing power structures, a common historical adaptation that legal scholar Reva Siegel coined as “preservation through transformation”(Siegel 1997). Michelle Alexander’s work on the rise of mass incarceration in “The New Jim Crow” highlights another historical juncture during which explicit institutional discrimination was replaced with more seemingly race neutral forms of racial containment and oppression (Alexander 2010). To this day, research has documented a strong correlation between non-white prison populations and the expansion of felony disenfranchisement policies (Behrens, Uggen, and Manza 2003).

A burgeoning body of literature that seeks to better define and measure the institutional mechanisms through which systemic racism operates on individual lives has identified the criminal legal system as one of the most influential institutions upholding the racial hierarchy in the United States (Chantarat, Van Riper, and Hardeman 2022; Lukachko, Hatzenbuehler, and Keyes 2014; Pettit and Western 2004; Wildeman 2012). One line of inquiry in this literature seeks to better understand the deleterious role of the unequal distribution of political power, either through representation in elected office or through restrictions on voting that disproportionately impact certain marginalized populations.

Felony disenfranchisement has similar consequences to other historical means of racialized voter suppression, such as the literacy tests and poll taxes that were levied on racially minoritized voters prior to the passage of the Voting Rights Act of 1965 as well as current day voter ID laws that disproportionately disenfranchise Black and Hispanic voters (Goldman 2004; Shah and Smith 2021). Another means of maintaining political power amongst dominant groups without the explicit exclusion of individual voters from the rolls occurs with the drawing of political boundaries to either isolate and/or dilute the representational power of marginalized communities (Behrens et al. 2003; Ewald 2012).

Evidence suggests that felony disenfranchisement has broader implications for political participation beyond the direct removal of those convicted of felonies from the electorate. Bowers and Preuhs found that strict FD laws reduce the probability of voting among non-felons in Black communities by “undermining the mechanism of political socialization” (Bowers and Preuhs 2009). A recent study in New York City also identified substantial spillover effects of felony disenfranchisement, with the neighborhoods that were home to “lost voters” turning out at lower rates than neighborhoods with similar characteristics (Morris 2021). A groundbreaking study by Christopher Uggen and Jeff Manza in 2002 used data from legal sources, election polls, and surveys of incarcerated persons to estimate the political consequences of felony disenfranchisement for specific electoral victories in the preceding years. They find that by removing a disproportionate number of racially minoritized and poor voters from the ranks, felony disenfranchisement played a substantial role in swaying U.S. Senate and presidential victories for more conservative candidates favored by majority high income and White voters (Uggen and Manza 2002).

The seemingly race-neutral nature of felony disenfranchisement quickly falls apart when one considers the deep racial inequalities in felony convictions that occur independently of underlying criminality. Black men experience the highest rates of system involvement and the earliest contacts with the system over the life course of any group (Boen et al. 2022; Brame et al. 2012; Hepburn, Kohler-Hausmann, and Zorro Medina 2019; Wildeman and Wang 2017). Thus, racialized political exclusion has deeper implications for the health and well-being of racially minoritized communities that are disproportionately entangled with the criminal legal system.

A pioneering study in this line of research by Lukachko et al (2014) used state-level measures of structural racism to investigate racialized patterns in myocardial infarction. A key dimension of structural racism that was found to increase risk of myocardial infarction for Blacks was unequal judicial treatment by the State, including higher rates of incarceration and disenfranchisement of Black citizens convicted of felonies. More recently, a study by Homan and Brown (2022) found that the disproportionate disenfranchisement of Black citizens at the state level was associated with increased risk of a range of poor physical and mental health outcomes, controlling for alternative explanatory factors at the state level such as poverty, income inequality, and incarceration rates (Homan and Brown 2022).

In 2013, Jonathan Purtle identified two potential pathways through which felony disenfranchisement could operate on health: 1) through the inability to vote in one's own self-interest and thus safeguard the allocation of resources to one's community, and 2) through the stress process and allostatic load, which could be triggered by an inability to reintegrate into society after incarceration (Purtle 2013). While Purtle focused on the theoretical impacts of racialized disenfranchisement on the health of the disenfranchised individual themselves, Homan and Brown consider both the direct impacts on those previously convicted of a felony and the indirect effects on the communities in which those individuals reside. Specifically, Homan and Brown's piece highlighted the weakening of Black voting power and the psychosocial consequences of racialized disenfranchisement that may trigger physiological dysregulation in both disenfranchised individuals and members of their communities.

The current study will focus on the potential implications of felony disenfranchisement for broader population health inequalities, namely birth weight and its risk factors. Given the gendered patterns of criminal legal system involvement, the pathways through which felony disenfranchisement are most likely to effect women's health and thus birth outcomes are through its impact on the well-being of women's families and communities and the degree to which racialized disenfranchisement serves as a signaling function to Black communities that they are excluded from political power. Furthermore, as Black and White communities are highly segregated, the deleterious effects of felony disenfranchisement on political participation and representation may be both concentrated in space within Black communities and compounded by the concentration of disadvantage in some Black neighborhoods.

One of the most powerful mechanisms through which structural racism operates on health is through the unequal distribution of health-related resources and socioeconomic opportunities to specific communities that concentrates disadvantage in communities of color (Massey and Denton 1993). The pattern of concentration and deprivation of resources and privilege that places a disproportionate social burden on predominantly Black neighborhoods then manifests in Black bodies.

As racialized disenfranchisement has been shown to sway elections in favor of more conservative politicians and policy agendas (Uggen and Manza 2002), the political and economic implications for racially minoritized communities may be detrimental. The political ideologies of conservative right-wing politicians have typically been characterized by more federalist and neoliberal ideas about government sponsored social safety nets, such as welfare and Medicaid. Historically, federalism has been grounded in efforts to exclude racially minoritized groups from the welfare state (Schram, Soss, and Fording 2003). Therefore, dilution of Black voting power through racialized felony disenfranchisement could lead to an overall erosion of social safety nets through the overrepresentation of federalist ideals and disinvestment in poverty alleviation efforts, particularly in Black communities.

Conservative focus on individual responsibility and demands for work requirements in social welfare policy are grounded in racist ideas that problematize the so-called "culture of poverty" and overlook the underlying drivers of racialized poverty, including fundamental change in labor market opportunities for low-skilled workers in American inner cities and the segregation of under-resourced Black neighborhoods. UCSC Politics Professor Michael K. Brown writes in his chapter on *Ghettos, Fiscal Federalism, and Welfare Reform:*

> "Equally important to these well-known causes of racialized poverty is one that often goes unstated: public disinvestment in ghetto communities. The problem with governmental policy is not that is has been too generous or that it contributes to the bad behavior of poor women. Rather, it has always been insufficient." (2003:50)

In this study, I hypothesize a link between racialized political exclusion, as precipitated by felony disenfranchisement, and birth outcomes through the restriction of Black voting power and the undermining of Black political participation. While some evidence exists linking adult functional limitations with racialized felony disenfranchisement (Homan and Brown 2022), no other study looks at the association between racialized felony disenfranchisement and long-standing racialized disparities in birth outcomes.

The current study makes an important contribution to our understanding of the growing role of the criminal legal system in maintaining and exacerbating racial health inequality. Importantly, looking at birth outcomes in 2018, this paper investigates the birth weights of infants born to people who were themselves born during the rise of mass incarceration in the 1980s and 1990s and thus will have had unique exposures to the consequences of felony disenfranchisement during formative/critical periods throughout their early life course. It is especially important to understand how rapid growth in the disenfranchised population over the past 3-4 decades may have contributed to widening disparities in birth outcomes by race and SES through political disempowerment and further marginalization of Black communities and families.

Aim

Empirically, the current study investigates the association between racialized disenfranchisement at the state level and individual level birth weight and chronic hypertension, which patterns birth weight risks.

Methods

Data and Measures

The individual-level data used in this study come from completed birth certificates for singleton first births to US-born non-Hispanic White and non-Hispanic Black people in 2018. The key dependent variables are low birth weight, measured as a dichotomous variable equaling 1 if birthweight is 2,499 grams or less and zero if birth weight is at least 2,500 grams, and chronic hypertension, recorded as a dichotomous variable. The key individual-level control variables include southern state residence, maternal age, maternal height, infant sex, Medicaid enrollment status, and marital status. Southern state residence is measured as a dichotomous variable equaling 1 if the birthing person is a current resident of a state that was ever part of the confederacy during the US Civil War and zero otherwise. These include Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, Virginia, Missouri, and Kentucky. The inclusion of this variable is consistent with the Homan and Brown study on racialized disenfranchisement and adult health outcomes, which controlled for Southern state residence "to reduce the potential for spurious relationships because the South is characterized by larger Black populations, distinct forms of historical racism, and poor population health for a variety of reasons."

Maternal age is a continuous variable centered at the overall mean for interpretability. Maternal height, shown in previous studies to be associated with birth weight and preterm birth risk (Dickey et al. 2012), is also measured as a continuous variable, in inches, centered at the overall mean. Infant sex is a dichotomous variable equaling 1 for male and 0 for female. Medicaid enrollment status and marital status are both dichotomous variables. Of the 3,801,534 births recorded that year, 525,991 births met the inclusion criteria and had complete information on key variables. A detailed table of sample inclusion criteria and missing observations is included in the appendix (See Table A3.1).

Observations that had infeasible birth weight for gestational age were excluded from the analysis and any observations with either missing gestational age information or a gestational age recording below 21 weeks or above 44 weeks. Any observations with missing information on key dependent and independent variables were excluded via listwise deletion.

The key independent variable is racialized disenfranchisement, which represents the degree of overrepresentation of Black citizens in the disenfranchised population and is defined as the ratio of the percentage of the disenfranchised population that is Black to the percentage of the total voting age (18+) population that is Black. Data on racialized disenfranchisement and the racial composition of the voting age population come from the Sentencing Project (https://www.sentencingproject.org/) (Uggen et al. 2016). Observations from Maine, Vermont, and the District of Columbia were excluded from the analysis. Maine and Vermont have no existing policies that disenfranchise people convicted of felonies, even while they are imprisoned. While this is also true of DC today, the felony disenfranchisement policy in DC was not repealed until 2020 and thus was still in effect at the time of this study. However, no data on felony disenfranchisement rates were available for DC from the Sentencing Project. I also include a variable for the percentage of the state-level voting-age population that is Black to account for the relative size and thus potential for political power and influence of the Black population in a given state. Both measures are standardized to mean=0, standard deviation=1 for interpretability.

I control for the incarceration rate at the state-level to address the alternative explanation that racialized disenfranchisement is associated with birth outcomes solely because of the correlation between incarceration rates and disenfranchisement rates. I also control for the state-level crime rate to falsify the alternative explanation that the association between racialized disenfranchisement and birth outcomes are explained by higher exposure to crime in areas where disenfranchisement is high. Both the incarceration rate and crime rate are captured in the year 2016 to mirror data on disenfranchisement and come from the Bureau of Justice Statistics (https://bjs.ojp.gov/). Both measures are standardized to mean 0, standard deviation 1 for comparability and interpretability of results.

To account for potential confounding of the relationship between racialized disenfranchisement and health by poverty and income inequality, I also control for the state-level poverty rate and the Gini index. The gini index or gini coefficient is a measure of income inequality. A value of 0 indicates perfect income equality (i.e., everyone has the same level of income) and a value of 1 indicates perfect inequality (i.e., one person holds all of the income while everyone else has zero income). I draw this data from the publicly available Correlates of State Policies Project dataset. Gini index measures come from 2017.

The state-level poverty rate is defined as the percentage of the population living at or below the federal poverty level. I draw this data from the 2018 American Community Survey Data, drawn from IPUMS USA (https://usa.ipums.org/usa/) a project at the University of Minnesota Population Center that provides harmonized census and survey data that is "integrated across time and space." Poverty rate is also standardized in the regression analysis for ease of interpretation. Because of the correlation between contact with the criminal legal system and poverty, controlling for both poverty and income inequality at the state level addresses the alternative explanation that the relationship between racialized disenfranchisement and birth outcomes is confounded by disparate rates of poverty.

In supplementary analyses, I also tested the inclusion of other correlates of state policy indicators, such as a policy liberalism score, which did not affect the results and were thus removed from the final paper.

Descriptive analyses also include individual-level data on maternal health characteristics such as chronic and gestational hypertension and diabetes, eclampsia, and timing of prenatal care initiation as well as maternal educational attainment. These factors were included in the descriptive analysis as an exploration of potential health-related mechanisms through which the independent variables may operate on the outcomes of low birth weight. Since they were not included in the final regression analysis, observations missing information on these variables were still included in the final regression analysis.

Methods

I generated summary statistics of key analytic and descriptive variables for the full sample and for Black and White births separately, using t-tests to test for significant differences in mean values between Black and White births in 2018 across each characteristic. To answer the primary research question, I ran race-stratified multi-level mixed-effect logistic regression models to assess the association between state-level racialized disenfranchisement on risk of low birth weight and a key pregnancy-related risk factor for low birth weight: chronic hypertension, separately, controlling for other state and individual level confounding variables. Random intercepts and slopes for states account for the variation across geographies and predictors that may explain geographic differences in the effects of racialized disenfranchisement across states.

I then generated and plotted the predicted probabilities of low birth weight and chronic hypertension, by race, across levels of racialized disenfranchisement.

Results

Table 3.1 describes the characteristics of the sample as a whole and stratified by race. This analysis describes state and individual level correlates with birth weight, hypertension, and racialized disenfranchisement as well as the maternal health factors that may be shaped by the processes under study. I used t-tests to test for significant differences in group means between Black and White births and found that all factors except for the Gini coefficient were significantly different between Black and White births at the p<0.01 level and thus p-values and significance stars are not included in the table for readability.

Tables 3.2 and 3.3 detail the results of the multi-level mixed effects logistic regression models for low birth weight and chronic hypertension respectively. Coefficients are exponentiated and results are expressed as odds ratios. Table 3.2 indicates that racialized disenfranchisement is not associated with low-birth-weight risk for White births. The only state-level factor that is associated with increased risk of low birth weight for White births is the poverty rate, with White births exposed to a one standard deviation increase in poverty being at 6% greater odds of having a low-birth-weight birth than White births exposed to mean levels of state-level poverty. Conversely, a one standard deviation increase in racialized disenfranchisement is associated with a 10% increased odds of low birth weight for Black births after controlling for other potential confounders of the association at the state level. Figure 3.1, Panel A graphically displays the predicted probability of low birth weight across levels of racialized disenfranchisement for White vs. Black births.

Table 3.3 describes the corresponding regression results for the outcome of chronic hypertension among birthing people. A one standard deviation increase in racialized disenfranchisement is associated with a non-significant increase in odds of chronic hypertension for White births and a 42% increase in odds of chronic hypertension for Black births. Figure 3.1, Panel B graphically displays the predicted probabilities of odds of chronic hypertension across levels of racialized disenfranchisement in the X-axis. The slope for White births across levels of racialized disenfranchisement is not significantly different from zero, but there is a significant increase in risk of chronic hypertension with increasing levels of racialized disenfranchisement for Black births.

Discussion

This study places modern racial health inequalities in a historical and political context. Many of the pathways through which systemic racism operates on the health and well-being of racially minoritized groups today are the result of exposure to deeply ingrained historical processes that were designed to sequester social, political, and economic power among dominant groups. Where we do not see a strong relationship between disenfranchisement and risk of low birth weight nor hypertension among White birthing people, the associations are strongest for Black births.

These findings add evidence to a nascent body of research that aims to identify and measure institutional mechanisms and historical processes that underlie racial disparities in health and wellbeing today. Vast racial disparities in criminal legal system involvement and exposure to concentrated neighborhood poverty are not new and they are not accidental. The current study makes an important contribution to understanding a key institutional mechanism upholding structural racism through policies that have been in place for nearly 200 years and have received new attention and salience in the wake of recent mass incarceration throughout the 1980s and 1990s. Importantly, we see a particularly strong association with chronic hypertension among birthing people, which suggests that the mechanisms through which racialized disenfranchisement operate on birth outcomes may emerge prior to conception, which has important implications from a life course perspective. By investigating how racialized disenfranchisement is associated with racialized patterns of birth weight outcomes for a cohort that has come of age during the rise of mass incarceration, we are potentially capturing the consequences of unique stress exposures during critical periods throughout the pre-conception life course.

Limitations

This study has a few key limitations that are worth noting and suggest areas for improvement in future research on this topic. First, using administrative birth record data for the individual level outcome limits our ability to introduce nuance into the psychosocial mechanisms that may underlie these processes. Future research may utilize survey research to capture more of these important processes. Second, this paper uses cross-sectional analysis. Future research using longitudinal data would improve our ability to make causal inferences.

Conclusion

In addition to heightened risk of low birth weight for births to Black people exposed to higher levels of racialized disenfranchisement, I also find a particularly strong association between racialized disenfranchisement and chronic hypertension. Chronic hypertension is a key health risk factor for adverse birth outcomes, including low birth weight. Thus, this association suggests that the mechanism through which racialized disenfranchisement operates on birth outcomes may emerge prior to conception, which has important implications from a life course perspective.

This investigation is particularly salient for a cohort of birthing people that came of age during the rise of mass incarceration and may have had unique stress exposures throughout critical periods of the pre-conception life course that are related to criminal legal system exposures and political disempowerment of their families and communities through felony disenfranchisement.

This study places modern racial health inequalities in a historical and political context. The results add to a body of evidence that suggest the pathways through which systemic racism operate on the health and well-being of racially minoritized groups today are the result of exposure to deeply ingrained historical processes that were designed to sequester social, political, and economic power among dominant groups.

Chapter 3 Tables and Figures

FIGURE 3.1: Map of State-Level Felony Disenfranchisement Laws

Source: [American Civil Liberties Union]

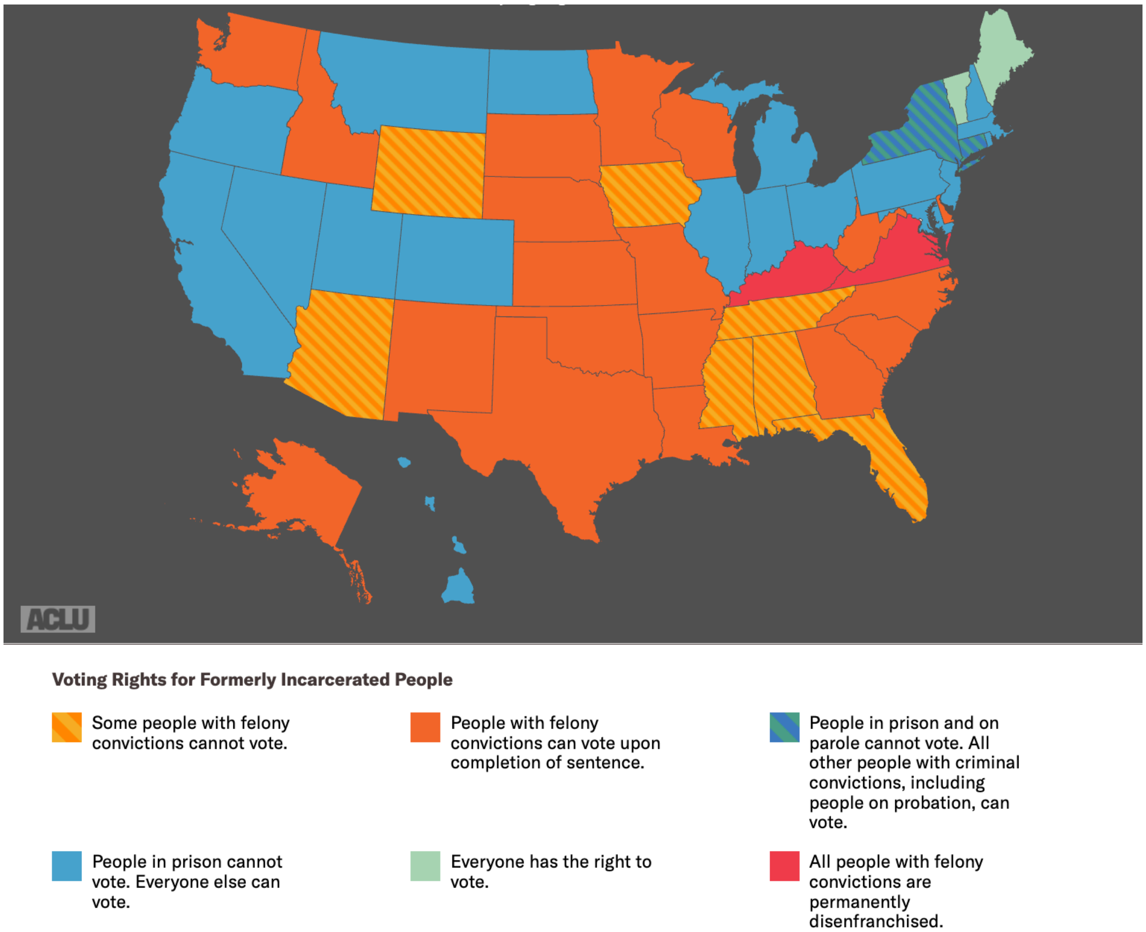


TABLE 3.1: State and Individual-Level Sample Characteristics, by Race

	Total (N=525,991)				White (N = 410,652)		Black (N=115,339)	
	Mean; %	SD	Min	Max	Mean	SD	Mean	SD
State-Level Characteristics								
Racialized FD	3.43	1.20	1.65	8.64	3.56	1.23	2.95	0.95
Gini Coefficient	0.47	0.04	0.18	0.52	0.47	0.04	0.47	0.06
Poverty Rate	0.12	0.03	0.07	0.19	0.11	0.03	0.12	0.03
Incarceration (per 1K)	4.25	1.38	1.38	7.62	4.15	1.36	4.59	1.36
Crime rate (per 100K pop)	0.42	0.49	0.00	1.00	0.37	0.48	0.58	0.49
Individual Characteristics								
Southern residence	0.42	0.49	0.00	1.00	0.37	0.48	0.58	0.49
Birth weight (g)	3238.58	579.96	227.00	5642.00	3297.60	553.87	3028.46	620.57
Low Birth Weight	0.08	0.27	0.00	1.00	0.07	0.25	0.14	0.35
Gestational Age (weeks)	38.74	2.41	21.00	44.00	38.87	2.24	38.25	2.89
Pre-Term Birth	0.11	0.31	0.00	1.00	0.09	0.29	0.15	0.36
Chronic Hypertension	0.02	0.15	0.00	1.00	0.02	0.14	0.03	0.18
Gestational hypertension	0.11	0.31	0.00	1.00	0.11	0.31	0.12	0.32
Diabetes	0.06	0.24	0.00	1.00	0.07	0.25	0.05	0.22
Eclampsia	0.00	0.06	0.00	1.00	0.00	0.06	0.00	0.06
Maternal height (inches)	64.58	2.73	30.00	78.00	64.65	2.71	64.31	2.81
Maternal age	26.01	5.56	15.00	49.00	26.66	5.47	23.69	5.25
Married	0.50	0.50	0.00	1.00	0.60	0.49	0.13	0.34
HS or Less	0.36	0.48	0.00	1.00	0.31	0.46	0.53	0.50
Some College	0.30	0.46	0.00	1.00	0.29	0.46	0.33	0.47
College +	0.34	0.47	0.00	1.00	0.40	0.49	0.14	0.35
Medicaid Insurance	0.37	0.48	0.00	1.00	0.29	0.45	0.67	0.47
Private Insurance	0.59	0.49	0.00	1.00	0.67	0.47	0.30	0.46
1st PNC in 1st Tri.	0.81	0.39	0.00	1.00	0.84	0.37	0.70	0.46
1st PNC in 2nd Tri	0.14	0.35	0.00	1.00	0.12	0.33	0.22	0.41
1st PNC in 3rd Tri	0.03	0.18	0.00	1.00	0.03	0.16	0.05	0.22
No PNC Visits	0.01	0.11	0.00	1.00	0.01	0.09	0.02	0.15

Racialized disenfranchisement = % disenfranchised population that is Black / % of the voting age population that is Black.

All state-level characteristics are standardized to mean=0, standard deviation=1.

t-tests indicate that all Black-White differences are statistically significant (p-values and stars suppressed from the table).

TABLE 3.2: Adjusted odds ratios from multi-level mixed effects logistic regressions of individual and state-level characteristics on odds of chronic hypertension and low birth weight, stratified by race

	Chronic Hypertension				Low Birth Weight			
	White		Black		White		Black	
	OR	(se)	OR	(se)	OR	(se)	OR	(se)
State-Level Characteristics								
Racialized Disenfranchisement	1.03	(0.07)	1.38 **	(0.14)	0.99	(0.03)	1.10 **	(0.03)
Incarceration Rate	0.98	(0.05)	1.01	(0.06)	0.98	(0.02)	1.00	(0.02)
Crime Rate	1.03	(0.05)	1.02	(0.06)	1.01	(0.02)	1.02	(0.02)
Gini Coefficient	1.03	(0.04)	0.98	(0.03)	0.97 *	(0.02)	0.98 **	(0.01)
Poverty Rate	1.24 ***	(0.07)	1.11	(0.08)	1.07 **	(0.03)	1.04 ~	(0.02)
% Voting Age Population Black	1.03	(0.05)	1.15 *	(0.06)	0.98	(0.02)	1.01	(0.01)
Southern region	0.90	(0.10)	1.16	(0.14)	0.99	(0.05)	1.14 ***	(0.04)
Individual-Level Characteristics								
Maternal Age	1.11 ***	(0.00)	1.15 ***	(0.00)	1.05 ***	(0.00)	1.05 ***	(0.00)
Maternal Height	1.03 ***	(0.00)	1.06 ***	(0.01)	0.90 ***	(0.00)	0.92 ***	(0.00)
Male Infant	1.04 *	(0.02)	1.00	(0.03)	0.83 ***	(0.01)	0.81 ***	(0.01)
Medicaid enrollment	1.16 ***	(0.04)	1.18 ***	(0.05)	1.24 ***	(0.02)	1.07 **	(0.02)
Marital Status	0.98	(0.03)	0.97	(0.05)	0.79 ***	(0.01)	0.85 ***	(0.03)
Maternal Education								
HS or Less	1.00		1.00		1.00		1.00	
Some College	0.97	(0.03)	0.81 ***	(0.03)	0.76 ***	(0.01)	0.81 ***	(0.02)
College +	0.62 ***	(0.02)	0.63 ***	(0.03)	0.59 ***	(0.01)	0.67 ***	(0.02)
Intercept	0.02 ***	(0.00)	0.04 ***	(0.00)	0.10 ***	(0.00)	0.20 ***	(0.01)
State-Level Variance	0.04	(0.01)	0.03	(0.01)	0.01	(0.00)		(0.00)

***p<0.001; **p<0.01; *p<0.05; ~p<0.10

Racialized disenfranchisement is defined as the percentage of the disenfranchised population that is Black divided by the percentage of the voting age population that is Black.

The incarceration rate, crime rate, poverty rate, and proportion of the voting age population that are Black are all standardized at a mean of zero and standard deviation of one.

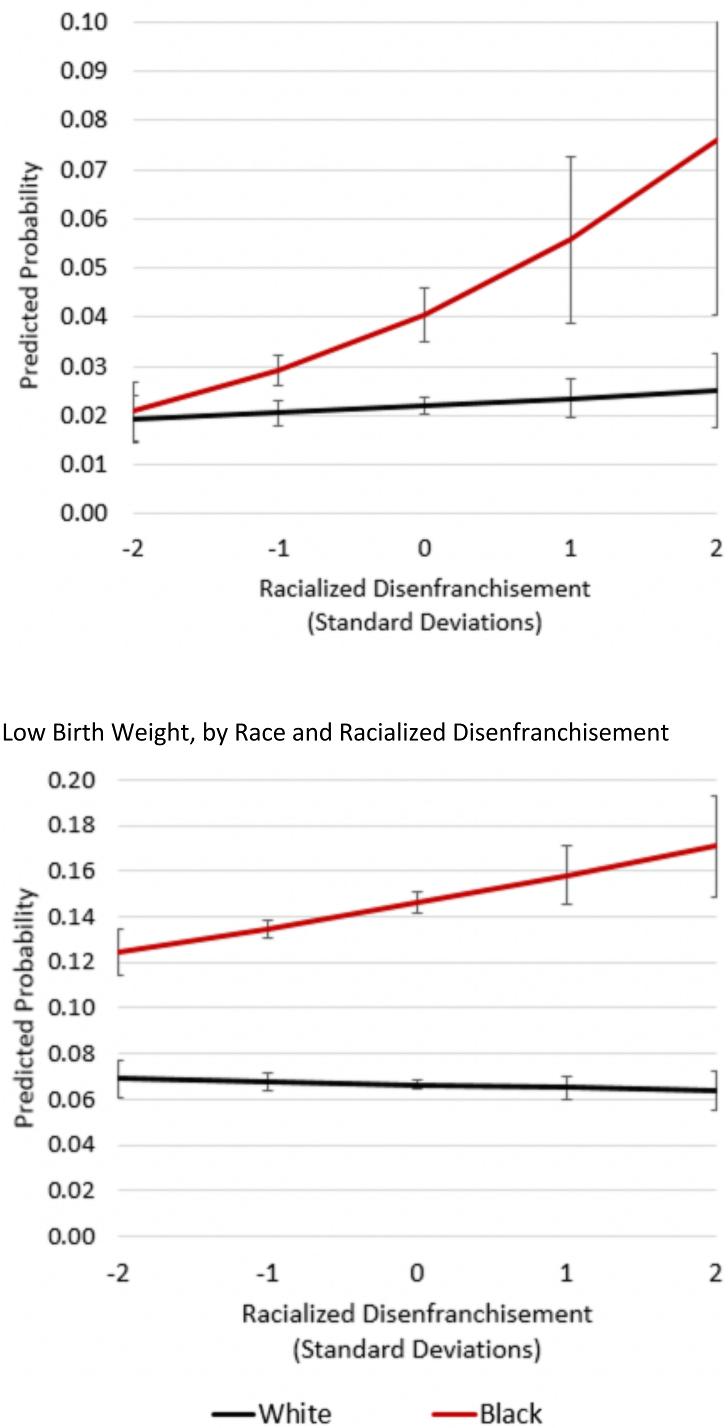
Medicaid enrollment is determined based on payment for birth as recorded on the birth certificate.

Coefficients are exponentiated and displayed as odds ratios.

FIGURE 3.2: Predicted Probabilities of Low Birth Weight and Chronic Hypertension, by State-Level Racialized Disenfranchisement

(A) Chronic Hypertension, by Race and Racialized Disenfranchisement

(A) Low Birth Weight, by Race and Racialized Disenfranchisement



CONCLUSION

Racial disparities in birth outcomes in the United States have been stark and persistent across time. Despite much attention given to investigating the patterns and drivers of these disparities, the underlying mechanisms through which racial birth weight disparities emerge and are reproduced across generations are still not well understood. This dissertation investigated the racialized patterns of inequality in United States' birth weight outcomes over the past three decades in three important ways. In the first chapter, I identified three large demographic shifts that have shaped racialized patterns of very low and moderately low birth weight over time. Revisiting the weathering and diminishing returns hypotheses, the findings of this analysis have important implications for population level shifts in the level of participation in institutions of marriage and education and the timing of births on racialized age patterns of low-birth-weight risk. Educational expansions have not had a narrowing effect on racial disparities in birth outcomes and through diminished returns to educational attainment for Black lives, educational expansion may contribute to wider racial disparities in risk of low birth weight. Conversely, increases in non-marital childbearing, often highlighted as a key mechanism patterning racial disparities in birth outcomes has diminished in importance for explaining these gaps over time.

In the second chapter, I identified that increased labor inductions and cesarean sections contribute a similar shortening of the expected gestational length for Black births, but this shortening is offset by simultaneous decreases in the probability of birth without obstetric intervention at earlier gestational ages, when birth weights are lowest. Thus, higher levels of obstetric intervention among Black births are an important driver of racial differences in average gestational length and thus birth weight disparities, but the overall increase in obstetric intervention among all births has narrowed the racial gap in gestational length and birth weight without substantive improvements in mean birth weights for Black births born at term.

Lastly, the third chapter took a macro-level perspective on racial disparities in birth outcomes to investigate the associations with a key institutional mechanism of structural racism: the disproportionate incarceration and subsequent disenfranchisement of Black citizens. I found a strong effect of racialized disenfranchisement on risk of low birth weight and chronic hypertension among birthing people, which is an important risk factor for adverse birth outcomes that often emerges pre-conception.

Taken together, these three papers highlight the importance of understanding not just the distribution of risk and protective factors, by race, but the broader institutional forces at play in producing racialized disparities in outcomes. Expansion of educational attainment is only valuable as an equalizing force if health and economic dividends from education are racially equitable. Similarly, potentially life-saving obstetric interventions that are implemented under professional guidelines that essentialize race could result in further marginalization of Black birthing people within the healthcare system. Lastly, the implementation of seemingly race-neutral policies that have clear disparate impacts on racially minoritized groups are the most insidious tools used to perpetuate structural racism. To be truly anti-racist policies need to be evaluated not just on their internal logic but on the degree to which they promote or restrict racial equity in health and economic wellbeing.

APPENDIX

TABLE A1.1: Summary of Chapter 1 Sample Eligibility and Missing Observations, by Year

	1990						2018					
Variable	No/Not Elig.		Yes/Eligible		Missing		No/Not Elig.		Yes/Eligible		Missing	
(inclusion criteria)	N	%	N	%	N	%	N	%	N	%	N	%
Inclusion Criteria												
Mother Aged 23-49	1,133,405	28.5%	2,845,768	72%	-	0%	546,212	15.7%	2,931,372	84%	-	0%
Non-Hispanic	591,932	15%	3,292,315	83%	94,926	2%	874,922	25%	2,575,632	74%	27,030	<1%
US Born	526,493	13%	3,445,075	87%	7,605	<1%	655,598	19%	2,815,702	81%	6,284	<1%
Singleton fetus	93,836	2%	3,885,337	98%	-	0%	118,014	3%	3,359,570	97%	-	0%
Gestational Age 21-44	59,779	2%	3,876,529	97%	42,865	1%	26,598	<1%	3,448,644	99%	2,342	<1%
Live birth order =1	2,337,537	59%	1,616,039	41%	25,597	<1%	2,167,367	62%	1,300,095	37%	10,122	<1%
Facility Birth	30,225	<1%	3,947,329	99%	1,619	<1%	40,330	1.2%	3,437,020	99%	234	<1%
Independent Variables												
Maternal Education	-	0%	3,701,294	93%	277,879	7%	-	0%	3,437,643	99%	39,941	1%
Marital Status	-	0%	3,979,173	100%	-	0%	-	0%	3,477,584	100%	-	0%
Dependent Variable												
Birth weight	-	0%	3,974,070	100%	5,103	<1%	-	0%	3,474,817	100%	2,767	<1%
Quality Check												
Birth weight for GA	853	<1%	3,932,066	99%	46,254	1%	760	<1%	3,472,467	100%	4,357	<1%
Total	3,010,271	76%	660,811	17%	308,091	8%	2,480,751	71%	591,823	17%	405,010	12%

Chapter 1 Analytic Sample Size: **1,252,634**

TABLE A1.2a: Relative Risk Ratios of **Very Low Birth Weight** from Multinomial Logistic Regression of Maternal Characteristics on Birth Weight Category (stepwise models not included in final paper)

		Model 1 (Base) Race, Age, & Year		Model 2 + Education		Model 3 + Marriage		Model 4 (Full) + Edu. & Marriage	
		RRR	(se)	RRR	(se)	RRR	(se)	RRR	(se)
Year 2018 (Ref:1990)		1.37 ***	(0.07)	1.56 ***	(0.09)	1.01	(0.06)	1.11	(0.07)
Black		3.86 ***	(0.22)	3.57 ***	(0.22)	2.52 ***	(0.17)	2.48 ***	(0.17)
Year*Black		0.81 **	(0.06)	0.76 **	(0.07)	1.02	(0.09)	1.01	(0.10)
Age:	23-24	1.00		1.00		1.00		1.00	
	25-29	0.90 *	(0.04)	1.00	(0.04)	0.96	(0.04)	1.04	(0.04)
	30-34	1.23 ***	(0.06)	1.45 ***	(0.07)	1.32 ***	(0.06)	1.50 ***	(0.07)
	35-39	1.75 ***	(0.10)	2.13 ***	(0.12)	1.84 ***	(0.10)	2.16 ***	(0.13)
	40+	2.31 ***	(0.26)	2.87 ***	(0.33)	2.34 ***	(0.27)	2.83 ***	(0.32)
Year*Age:	23-24	1.00		1.00		1.00		1.00	
	25-29	1.00	(0.06)	1.12 ~	(0.07)	1.05	(0.07)	1.11 ~	(0.07)
	30-34	0.77 ***	(0.05)	0.94	(0.06)	0.86 *	(0.06)	0.95	(0.06)
	35-39	0.74 ***	(0.06)	0.88	(0.07)	0.83 *	(0.07)	0.90	(0.07)
	40+	0.88	(0.12)	1.03	(0.15)	0.98	(0.14)	1.06	(0.15)
Black*Age	23-24	1.00		1.00		1.00		1.00	
	25-29	1.14 ~	(0.08)	1.08	(0.08)	1.12	(0.08)	1.06	(0.08)
	30-34	1.20 *	(0.09)	1.12	(0.09)	1.19 *	(0.09)	1.11	(0.09)
	35-39	1.05	(0.11)	0.97	(0.11)	1.07	(0.12)	0.98	(0.11)
	40+	1.05	(0.24)	0.94	(0.22)	1.10	(0.25)	0.98	(0.23)
Year*Black*Age:	23-24	1.00		1.00		1.00		1.00	
	25-29	1.13	(0.11)	1.04	(0.10)	1.06	(0.10)	1.03	(0.10)
	30-34	1.30 *	(0.14)	1.17	(0.13)	1.21 ~	(0.13)	1.16	(0.13)
	35-39	1.34 *	(0.19)	1.28 ~	(0.18)	1.28 ~	(0.18)	1.27 ~	(0.18)
	40+	0.87	(0.24)	0.87	(0.24)	0.84	(0.23)	0.85	(0.23)
Education:	HS or Less			1.00				1.00	
	Some Coll.			0.72 ***	(0.03)			0.76 ***	(0.03)
	College+			0.57 ***	(0.02)			0.61 ***	(0.02)
Year*Edu.	HS or Less			1.00				1.00	
	Some Coll.			0.96	(0.05)			0.95	(0.05)
	College+			0.74 ***	(0.04)			0.76 ***	(0.04)
Black*Edu.	HS or Less			1.00				1.00	
	Some Coll.			1.19 **	(0.07)			1.19 **	(0.08)
	College+			1.16 *	(0.08)			1.17 *	(0.09)
Year*Black*Education									
	HS or Less			1.00				1.00	
	Some Coll.			0.96	(0.08)			0.94	(0.08)
	College+			1.11	(0.11)			1.05	(0.10)
Married						0.51 ***	(0.02)	0.57 ***	(0.02)
Year*Married						1.20 ***	(0.06)	1.36 ***	(0.07)
Black*Married						1.45 ***	(0.09)	1.39 ***	(0.09)
Year*Black*Married						0.82 *	(0.07)	0.78 **	(0.07)
Intercept		0.01 ***	(0.00)	0.01 ***	(0.00)	0.01 ***	(0.00)	0.01 ***	(0.00)

TABLE A1.2b: Relative Risk Ratios of **Moderately Low Birth Weight** from Multinomial Logistic Regression of Maternal Characteristics on Birth Weight Category (stepwise models not included in final paper)

		Model 1 (Base) Race, Age, & Year			Model 2 + Education			Model 3 + Marriage			Model 4 (Full) + Edu. & Marriage		
		RRR		(se)	RRR		(se)	RRR		(se)	RRR		(se)
Year 2018 (Ref:1990)		1.31	***	(0.03)	1.42	***	(0.04)	1.01		(0.03)	1.10	**	(0.03)
Black		2.28	***	(0.07)	2.26	***	(0.07)	1.67	***	(0.06)	1.74	***	(0.06)
Year*Black		0.91	*	(0.04)	0.82	***	(0.04)	1.04		(0.05)	0.98		(0.05)
Age:	23-24	1.00			1.00			1.00			1.00		
	25-29	1.01		(0.02)	1.12	***	(0.02)	1.07	***	(0.02)	1.16	***	(0.02)
	30-34	1.25	***	(0.02)	1.49	***	(0.03)	1.33	***	(0.03)	1.53	***	(0.03)
	35-39	1.61	***	(0.04)	1.98	***	(0.05)	1.67	***	(0.04)	2.01	***	(0.05)
	40+	1.98	***	(0.11)	2.51	***	(0.14)	2.01	***	(0.11)	2.48	***	(0.13)
Year*Age:	23-24	1.00			1.00			1.00			1.00		
	25-29	0.92	**	(0.03)	0.98		(0.03)	0.97		(0.03)	0.99		(0.03)
	30-34	0.80	***	(0.02)	0.90	***	(0.03)	0.89	***	(0.03)	0.92	**	(0.03)
	35-39	0.81	***	(0.03)	0.87	***	(0.03)	0.89	**	(0.03)	0.90	**	(0.03)
	40+	0.85	*	(0.06)	0.90		(0.06)	0.93		(0.06)	0.93		(0.06)
Black*Age	23-24	1.00			1.00			1.00			1.00		
	25-29	1.10	*	(0.04)	1.05		(0.04)	1.11	**	(0.04)	1.05		(0.04)
	30-34	1.06		(0.05)	1.00		(0.04)	1.10	*	(0.05)	1.02		(0.04)
	35-39	1.03		(0.06)	0.96		(0.06)	1.10		(0.07)	0.99		(0.06)
	40+	1.00		(0.14)	0.90		(0.13)	1.08		(0.15)	0.95		(0.13)
Year*Black*Age:	23-24	1.00			1.00			1.00			1.00		
	25-29	1.05		(0.05)	0.98		(0.05)	0.96		(0.05)	0.96		(0.05)
	30-34	1.10	~	(0.06)	1.01		(0.06)	0.99		(0.06)	0.98		(0.06)
	35-39	1.08		(0.08)	1.04		(0.08)	0.99		(0.08)	1.02		(0.08)
	40+	0.99		(0.16)	1.00		(0.16)	0.93		(0.15)	0.98		(0.16)
Education:	HS or Less				1.00						1.00		
	Some Coll.				0.72	***	(0.01)				0.74	***	(0.01)
	College+				0.55	***	(0.01)				0.58	***	(0.01)
Year*Edu.	HS or Less				1.00						1.00		
	Some Coll.				1.00		(0.02)				1.01		(0.02)
	College+				0.91	***	(0.02)				0.95	~	(0.02)
Black*Edu.	HS or Less				1.00						1.00		
	Some Coll.				0.99		(0.03)				1.01		(0.03)
	College+				1.05		(0.04)				1.12	**	(0.04)
Year*Black*Education													
	HS or Less				1.00						1.00		
	Some Coll.				1.13	**	(0.05)				1.08		(0.05)
	College+				1.18	**	(0.06)				1.05		(0.06)
Married								0.56	***	(0.01)	0.63	***	(0.01)
Year*Married								1.15	***	(0.03)	1.21	***	(0.03)
Black*Married								1.14	***	(0.04)	1.11	**	(0.04)
Year*Black*Married								1.02		(0.04)	0.97		(0.04)
Intercept		0.01	***	(0.00)	0.05	***	(0.00)	0.07	***	(0.00)	0.07	***	(0.00)

TABLE A2.1: Summary of Chapter 2 Sample Eligibility and Missing Observations, by Year

	1990						2018					
Variable	No/Not Eligible[1]		Yes/Eligible		Missing		No/Not Eligible		Yes/Eligible		Missing	
(eligibility criteria)	N	%	N	%	N	%	N	%	N	%	N	%
Inclusion Criteria: All Births												
US-born	515,993	13%	3,361,893	87%	7,451	<1%	636,306	19%	2,717,238	81%	6,026	<1%
Live birth order =1	2,263,403	58%	1,596,880	41%	25,054	<1%	2,076,307	62%	1,273,553	38%	9,710	<1%
Facility birth	29,890	<1%	3,853,869	99%	1,578	<1%	39,872	1%	3,319,466	99%	232	<1%
Mother aged 15-49	11,202	<1%	3,874,135	100%	-	<1%	2,587	<1%	3,356,983	100%		<1%
Non-Hispanic	581,015	15%	3,211,648	83%	92,674	2%	852,956	25%	2,480,798	74%	25,816	<1%
Inclusion Criteria: Low-Risk Births												
No chronic HBP	24,342	<1%	3,696,521	95%	164,474	4%	70,338	2%	3,286,523	98%	2,709	<1%
No gest. HBP	99,361	3%	3,621,502	93%	164,474	4%	239,269	7%	3,117,592	93%	2,709	<1%
No eclampsia	14,180	<1%	3,706,683	95%	164,474	4%	7,733	<1%	3,349,128	100%	2,709	<1%
No diabetes	77,317	2%	3,643,546	94%	164,474	4%	235,613	7%	3,121,248	93%	2,709	<1%
No tobacco use	530,869	14%	2,305,312	59%	1,049,156	27%	3,101,712	92%	229,508	7%	28,350	<1%
PNC in 1st Tri.	915,809	24%	2,888,621	74%	80,907	2%	744,785	22%	2,530,635	75%	84,150	3%
Vertex	124,227	3%	3,605,660	93%	155,450	4%	105,612	3%	3,242,996	97%	10,962	<1%
Independent Variables												
Vaginal delivery			3,764,697	97%	120,640	3%			3,358,065	100%	1,505	<1%
Cesarean			3,764,697	97%	120,640	3%			3,358,065	100%	1,505	<1%
Induced			3,747,610	96%	137,727	4%			3,355,652	100%	3,918	<1%
Dependent Variable												
Gestational age (LMP)	58,917	2%	3,784,551	97%	41,869	1%	25,683	<1%	3,331,599	99%	2,288	<1%
Quality Check												
Birth weight for GA	782	<1%	3,839,583	99%	44,972	1%	661	0%	3,354,873	100%	4,036	<1%
Total: All births	2,741,990	71%	984,532	25%	158,815	4%	2,612,934	78%	699,582	21%	47,054	1%
Total: Low risk births	1,978,393	51%	456,137	12%	1,450,807	37%	2,783,664	83%	415,466	12%	160,440	5%

Total analytic sample size: All births = **1,684,114**; Total analytic sample size: Low-risk Births = **871,603**

[1] Observations are deemed "not eligible" if they do not meet the inclusion criteria detailed for each variable. Observations that do not meet the inclusion criteria are removed from the analysis.

TABLE A2.2a: Characteristics of All **White** Births, by Delivery Method in 1990, 2018, and the Change Over Time (N=1,363,330)

	1990				2018				Change (2018-1990)[2]			
Delivery method[1]	SV	IND	CES	Total	SV	IND	CES	Total	SV	IND	CES	Total
	%; μ(sd)	%; μ(sd)	%; μ(sd)	%; μ(sd)	%; μ(sd)	%; μ(sd)	%; μ(sd)	%; μ(sd)	Δ%pts; Δμ	Δ%pts; Δμ	Δ%pts; Δμ	Δ%pts; Δμ
Maternal Age (yrs)	24.2	24.9	25.8	24.6	26.8	26.9	28.5	27.1	2.6 ***	2.0 ***	2.8 ***	2.5 ***
	(5.3)	(5.3)	(5.5)	(5.4)	(5.3)	(5.5)	(5.6)	(5.5)				
Birth Wgt (grams)	3,350	3,473	3,425	3,381	3,296	3,351	3,261	3,310	-53.5 ***	-121.5 ***	-164.3 ***	-70.7 ***
	(513.9)	(554.7)	(662.8)	(555)	(485.7)	(509.6)	(721)	(544.4)				
Gest. Age (weeks)	39.3	39.9	39.3	39.4	39.0	39.2	38.3	38.9	-0.4 ***	-0.6 ***	-1.0 ***	-0.5 ***
	(2.3)	(2.1)	(2.5)	(2.3)	(2.1)	(1.9)	(2.8)	(2.2)				
Gest. Age Category												
Early PT (21-33)	2.1	1.2	3.2	2.2	2.0	1.1	5.6	2.3	0.0	-0.1	2.4 ***	0.1 ***
Late PT (34-36)	6.0	4.7	6.2	5.9	6.0	5.3	9.4	6.3	0.0	0.5 ***	3.1 ***	0.4 ***
Early Term (37-38)	17.5	14.9	16.0	16.8	22.4	20.9	23.1	22.0	4.9 ***	5.9 ***	7.1 ***	5.1 ***
Full Term (39-40)	47.2	36.9	42.8	45.0	54.2	50.9	48.7	52.0	7.0 ***	14.0 ***	5.8 ***	7.0 ***
Late-Post T. (41+)	27.3	42.3	31.6	30.1	15.4	21.9	13.2	17.4	-11.9 ***	-20.4 ***	-18.4 ***	-12.7 ***
First PNC visit												
First Tri.	83.0	86.1	86.9	84.2	83.9	84.4	85.1	84.3	0.9 ***	-1.7 ***	-1.8 ***	0.1
Second Tri.	13.7	11.6	10.9	12.8	12.1	12.2	11.2	11.9	-1.7 ***	0.5 ***	0.3 **	-0.9 ***
Third Tri.	2.5	2.0	1.7	2.3	3.0	2.9	2.6	2.9	0.5 ***	0.9 ***	0.9 ***	0.6 ***
Never	0.8	0.2	0.5	0.7	1.1	0.5	1.1	0.9	0.3 ***	0.3 ***	0.6 ***	0.2 ***
Prenatal Smoking	17.9	16.1	17.0	17.5	6.7	7.4	6.7	7.0	-11.2 ***	-8.7 ***	-10.3 ***	-10.5 ***
Chronic HBP	0.3	1.7	0.9	0.6	0.6	3.1	2.4	1.9	0.3 ***	1.4 ***	1.5 ***	1.3 ***
Gestational HBP	2.2	14.1	6.0	4.5	3.7	18.2	10.1	10.3	1.4 ***	4.1 ***	4.1 ***	5.7 ***
Diabetes	1.2	4.1	2.7	1.9	3.4	8.2	7.4	5.9	2.2 ***	4.1 ***	4.7 ***	4.0 ***
Eclampsia	0.2	1.4	1.1	0.6	0.1	0.5	0.5	0.3	-0.2 ***	-0.9 ***	-0.6 ***	-0.3 ***
Breech	0.6	1.7	19.9	4.7	0.2	0.6	23.5	4.5	-0.4 ***	-1.1 ***	3.6 ***	-0.2 ***
Total N	531,329	102,417	161,398	795,144	255,396	212,016	100,774	568,186				
Total Row %	66.8	12.9	20.3	100.0	44.9	37.3	17.7	100.0	-21.9 ***	24.4 ***	-2.6 ***	

***p<0.001; **p<0.01; *p<0.05; ~p<0.1

TABLE A2.2b: Characteristics of All **Black** Births, by Delivery Method in 1990, 2018, and the Change Over Time (N= 293,703)

Delivery method[1]	1990 SV	1990 IND	1990 CES	1990 Total	2018 SV	2018 IND	2018 CES	2018 Total	Change (2018-1990)[2] SV	Change (2018-1990)[2] IND	Change (2018-1990)[2] CES	Change (2018-1990)[2] Total
	%; μ(sd)	%; μ(sd)	%; μ(sd)	%; μ(sd)	%; μ(sd)	%; μ(sd)	%; μ(sd)	%; μ(sd)	Δ%pts; Δμ	Δ%pts; Δμ	Δ%pts; Δμ	Δ%pts; Δμ
Maternal Age (yrs)	20.6	21.9	22.6	21.1	23.0	23.8	25.5	23.8	2.4 ***	1.9 ***	2.9 ***	2.6 ***
	(4.6)	(5.1)	(5.5)	(4.9)	(4.9)	(5.4)	(6)	(5.4)				
Birth Wgt (grams)	3,083	3,175	3,181	3,111	3,050	3,107	2,937	3,047	-33.1 ***	-67.8 ***	-243.6 ***	-63.9 ***
	(558.4)	(610.7)	(703.5)	(597.6)	(538.3)	(543.1)	(816.8)	(607.6)				
Gest. Age (weeks)	38.4	39.0	38.7	38.5	38.4	38.7	37.6	38.3	-0.1 ***	-0.3 ***	-1.1 ***	-0.2 ***
	(3.1)	(2.9)	(3.2)	(3.1)	(2.7)	(2.2)	(3.6)	(2.8)				
Gest. Age Category												
Early PT (21-33)	6.1	4.6	6.8	6.1	4.4	2.6	11.2	5.2	-1.7 ***	-2.0 ***	4.4 ***	-1.0 ***
Late PT (34-36)	10.8	9.4	9.4	10.4	8.4	8.1	11.5	8.9	-2.4 ***	-1.3 ***	2.1 ***	-1.5 ***
Early Term (37-38)	22.8	19.7	18.5	21.6	28.7	25.6	24.4	26.8	5.9 ***	5.9 ***	5.9 ***	5.2 ***
Full Term (39-40)	41.2	35.1	39.6	40.4	47.8	47.5	41.9	46.5	6.6 ***	12.4 ***	2.3 ***	6.2 ***
Late-Post T. (41+)	19.1	31.2	25.7	21.5	10.7	16.2	10.9	12.6	-8.5 ***	-15.0 ***	-14.8 ***	-8.9 ***
First PNC visit												
First Tri.	61.3	66.6	68.9	63.4	68.5	69.9	72.9	69.8	7.2 ***	3.3 ***	4.0 ***	6.4 ***
Second Tri.	29.7	26.6	24.6	28.3	22.3	22.8	19.7	21.9	-7.5 ***	-3.8 ***	-4.9 ***	-6.4 ***
Third Tri.	5.9	5.6	4.6	5.6	5.9	5.7	4.7	5.6	0.0	0.1	0.0	0.0
Never	3.1	1.1	1.8	2.7	3.4	1.6	2.7	2.7	0.3 ***	0.5 ***	0.9 ***	0.0
Prenatal Smoking	7.3	8.4	7.3	7.4	3.0	3.6	3.3	3.3	-4.3 ***	-4.8 ***	-4.0 ***	-4.1 ***
Chronic HBP	0.5	2.5	1.4	0.8	1.1	4.7	4.0	2.9	0.6 ***	2.3 ***	2.6 ***	2.0 ***
Gestational HBP	2.3	14.4	6.4	4.1	4.6	18.9	12.1	10.9	2.4 ***	4.6 ***	5.8 ***	6.7 ***
Diabetes	0.8	3.6	2.3	1.3	2.3	6.9	6.3	4.6	1.5 ***	3.3 ***	4.0 ***	3.3 ***
Eclampsia	0.5	2.9	2.0	1.0	0.1	0.6	0.9	0.4	-0.3 ***	-2.4 ***	-1.1 ***	-0.6 ***
Breech	0.6	1.3	9.2	2.3	0.4	0.5	10.2	2.4	-0.2 ***	-0.7 ***	1.1 **	0.0
Total N	116,603	13,821	32,889	163,313	61,395	43,344	25,651	130,390				
Total Row %	71.4	8.5	20.1	100.0	47.1	33.2	19.7	100.0	-24.3 ***	24.8 ***	-0.5 ***	

***p<0.001; **p<0.01; *p<0.05; ~p<0.1

Notes: Tables A2.2a-b describes all first singleton births to US-born non-Hispanic White and non-Hispanic Black people between the age of 15-49 who delivered in a health facility in 1990 or 2018. Life Table Analyses using this full sample are described in subsequent tables and figures in this appendix.; [1] SV = Spontaneous Vaginal delivery (i.e., no induction of labor); IND = Labor was either medically or surgically induced, delivery may have been vaginal or via cesarean; CES = Labor was not induced, delivery by cesarean section; [2] P-values are derived from t-tests for significant differences in year-specific means for continuous variables (age, birth weight, gestational age) and chi-square tests of proportions for gestational age category.

TABLE A2.3a: Age and delivery method decomposition of **change** in expected length of gestation between 1990 and 2018 among **low-risk White births**

	1990				2018				Decomposition			
GA_x	$_nm_x$	$_n\mathbf{R}_x^1$	$_n\mathbf{R}_x^2$	$_n\mathbf{R}_x^3$	$_nm_x$	$_n\mathbf{R}_x^1$	$_n\mathbf{R}_x^2$	$_n\mathbf{R}_x^3$	$_n\Delta_x$	$_n\Delta_x^1$	$_n\Delta_x^2$	$_n\Delta_x^3$
21-23	0.000	0.823	0.087	0.091	0.000	0.429	0.000	0.571	0.010	0.008	0.001	0.001
24	0.000	0.836	0.027	0.137	0.000	0.462	0.077	0.462	0.005	0.005	0.000	0.001
25	0.000	0.688	0.032	0.280	0.000	0.545	0.273	0.182	0.005	0.004	0.000	0.002
26	0.000	0.659	0.043	0.297	0.000	0.621	0.172	0.207	0.005	0.004	0.000	0.002
27	0.001	0.676	0.032	0.292	0.000	0.542	0.071	0.387	0.001	0.002	0.000	0.000
28	0.001	0.713	0.025	0.262	0.001	0.498	0.158	0.344	0.000	0.002	-0.001	-0.001
29	0.001	0.728	0.035	0.237	0.001	0.550	0.142	0.309	0.000	0.002	-0.001	-0.001
30	0.002	0.721	0.053	0.226	0.001	0.560	0.153	0.287	0.003	0.004	-0.001	0.000
31	0.002	0.740	0.048	0.212	0.002	0.551	0.140	0.309	0.001	0.004	-0.001	-0.001
32	0.003	0.748	0.064	0.188	0.003	0.563	0.159	0.278	0.002	0.005	-0.002	-0.001
33	0.005	0.759	0.064	0.177	0.004	0.575	0.179	0.246	0.004	0.007	-0.003	-0.001
34	0.009	0.764	0.068	0.168	0.008	0.551	0.223	0.226	0.003	0.012	-0.006	-0.002
35	0.015	0.764	0.084	0.152	0.013	0.570	0.220	0.210	0.009	0.018	-0.007	-0.002
36	0.028	0.768	0.091	0.141	0.027	0.578	0.246	0.176	0.005	0.021	-0.013	-0.003
37	0.058	0.767	0.096	0.137	0.067	0.551	0.286	0.164	-0.022	0.018	-0.033	-0.007
38	0.130	0.761	0.094	0.145	0.152	0.618	0.239	0.142	-0.034	0.008	-0.038	-0.004
39	0.305	0.757	0.092	0.151	0.451	0.534	0.318	0.147	-0.132	-0.009	-0.104	-0.018
40	0.595	0.731	0.103	0.166	0.823	0.522	0.351	0.127	-0.108	0.003	-0.108	-0.002
41	0.894	0.635	0.173	0.192	0.979	0.403	0.480	0.118	-0.019	0.039	-0.071	0.013
42-44	1.000	0.587	0.216	0.197	0.954	0.466	0.404	0.130	0.006	0.018	-0.021	0.009
								Sum	-0.256	0.171	-0.410	-0.018
								%	100%	-67%	160%	7%

$_n\Delta_x^1$ = Contribution of change in probability of **birth with no obstetric intervention** to the total change in gestational length
$_n\Delta_x^2$ = Contribution of change in probability of **birth from induced labor** to the total change in gestational length
$_n\Delta_x^3$ = Contribution of change in probability of **birth by cesarean section** to the total change in gestational length

TABLE A2.3b: Age and delivery method decomposition of **change** in expected length of gestation between 1990 and 2018 among **low-risk Black births**

	1990				2018				Decomposition			
GA_x	${}_nm_x$	${}_n\boldsymbol{R}_x^1$	${}_n\boldsymbol{R}_x^2$	${}_n\boldsymbol{R}_x^3$	${}_nm_x$	${}_n\boldsymbol{R}_x^1$	${}_n\boldsymbol{R}_x^2$	${}_n\boldsymbol{R}_x^3$	${}_n\Delta_x$	${}_n\Delta_x^1$	${}_n\Delta_x^2$	${}_n\Delta_x^3$
21-23	0.0009	0.877	0.021	0.102	0.0000	0.600	0.200	0.200	0.043	0.038	0.001	0.004
24	0.0014	0.792	0.040	0.168	0.0000	0.333	0.333	0.333	0.021	0.017	0.001	0.003
25	0.0018	0.762	0.048	0.190	0.0002	0.625	0.063	0.313	0.022	0.017	0.001	0.004
26	0.0020	0.757	0.029	0.214	0.0003	0.278	0.111	0.611	0.022	0.018	0.000	0.003
27	0.0020	0.782	0.042	0.176	0.0016	0.491	0.056	0.454	0.005	0.010	0.000	-0.004
28	0.0026	0.699	0.055	0.246	0.0017	0.451	0.150	0.398	0.010	0.012	-0.001	0.000
29	0.0035	0.783	0.037	0.180	0.0020	0.452	0.096	0.452	0.015	0.018	-0.001	-0.003
30	0.0049	0.728	0.060	0.213	0.0030	0.512	0.132	0.356	0.016	0.017	-0.001	0.000
31	0.0065	0.767	0.048	0.186	0.0038	0.519	0.136	0.345	0.020	0.023	-0.002	-0.001
32	0.0076	0.801	0.046	0.153	0.0048	0.515	0.157	0.327	0.019	0.024	-0.003	-0.003
33	0.0118	0.792	0.059	0.148	0.0079	0.541	0.144	0.315	0.022	0.029	-0.003	-0.004
34	0.0203	0.783	0.060	0.157	0.0139	0.534	0.204	0.263	0.031	0.040	-0.008	-0.002
35	0.0314	0.772	0.064	0.164	0.0214	0.545	0.232	0.223	0.038	0.047	-0.011	0.001
36	0.0489	0.785	0.060	0.154	0.0403	0.569	0.214	0.217	0.024	0.044	-0.016	-0.003
37	0.0933	0.779	0.064	0.158	0.1028	0.552	0.254	0.194	-0.019	0.031	-0.040	-0.010
38	0.1952	0.774	0.063	0.163	0.2272	0.612	0.232	0.156	-0.039	0.015	-0.050	-0.004
39	0.4000	0.758	0.060	0.183	0.5585	0.539	0.287	0.174	-0.108	0.002	-0.093	-0.016
40	0.6445	0.716	0.075	0.209	0.8759	0.490	0.336	0.174	-0.083	0.012	-0.088	-0.006
41	0.7902	0.644	0.110	0.246	0.9485	0.393	0.436	0.171	-0.028	0.024	-0.057	0.006
42-44	0.9272	0.624	0.136	0.240	0.8804	0.487	0.341	0.171	0.005	0.018	-0.020	0.008
								Sum	0.036	0.455	-0.391	-0.028
								%	100%	1249%	-1072%	-77%

${}_n\Delta_x^1$ = Contribution of change in probability of **birth with no obstetric intervention** to the total change in gestational length

${}_n\Delta_x^2$ = Contribution of change in probability of **birth from induced labor** to the total change in gestational length

${}_n\Delta_x^3$ = Contribution of change in probability of **birth by cesarean section** to the total change in gestational length

TABLE A2.3c: Age and delivery method decomposition of **racial gap** in expected length of gestation among **low-risk births in 1990**

	White				Black				Decomposition			
GA_x	${}_nm_x$	${}_n\boldsymbol{R}_x^1$	${}_n\boldsymbol{R}_x^2$	${}_n\boldsymbol{R}_x^3$	${}_nm_x$	${}_n\boldsymbol{R}_x^1$	${}_n\boldsymbol{R}_x^2$	${}_n\boldsymbol{R}_x^3$	${}_n\Delta_x$	${}_n\Delta_x^1$	${}_n\Delta_x^2$	${}_n\Delta_x^3$
21-23	0.000	0.823	0.087	0.091	0.001	0.877	0.021	0.102	-0.034	-0.034	-0.034	-0.034
24	0.000	0.836	0.027	0.137	0.001	0.792	0.040	0.168	-0.016	-0.016	-0.016	-0.016
25	0.000	0.688	0.032	0.280	0.002	0.762	0.048	0.190	-0.019	-0.019	-0.019	-0.019
26	0.000	0.659	0.043	0.297	0.002	0.757	0.029	0.214	-0.020	-0.020	-0.020	-0.020
27	0.001	0.676	0.032	0.292	0.002	0.782	0.042	0.176	-0.018	-0.018	-0.018	-0.018
28	0.001	0.713	0.025	0.262	0.003	0.699	0.055	0.246	-0.021	-0.021	-0.021	-0.021
29	0.001	0.728	0.035	0.237	0.004	0.783	0.037	0.180	-0.025	-0.025	-0.025	-0.025
30	0.002	0.721	0.053	0.226	0.005	0.728	0.060	0.213	-0.029	-0.029	-0.029	-0.029
31	0.002	0.740	0.048	0.212	0.006	0.767	0.048	0.186	-0.036	-0.036	-0.036	-0.036
32	0.003	0.748	0.064	0.188	0.008	0.801	0.046	0.153	-0.033	-0.033	-0.033	-0.033
33	0.005	0.759	0.064	0.177	0.012	0.792	0.059	0.148	-0.044	-0.044	-0.044	-0.044
34	0.009	0.764	0.068	0.168	0.020	0.783	0.060	0.157	-0.060	-0.060	-0.060	-0.060
35	0.015	0.764	0.084	0.152	0.031	0.772	0.064	0.164	-0.069	-0.069	-0.069	-0.069
36	0.028	0.768	0.091	0.141	0.049	0.785	0.060	0.154	-0.068	-0.068	-0.068	-0.068
37	0.058	0.767	0.096	0.137	0.093	0.779	0.064	0.158	-0.088	-0.088	-0.088	-0.088
38	0.130	0.761	0.094	0.145	0.195	0.774	0.063	0.163	-0.110	-0.110	-0.110	-0.110
39	0.305	0.757	0.092	0.151	0.400	0.758	0.060	0.183	-0.100	-0.100	-0.100	-0.100
40	0.595	0.731	0.103	0.166	0.644	0.716	0.075	0.209	-0.027	-0.027	-0.027	-0.027
41	0.894	0.635	0.173	0.192	0.790	0.644	0.110	0.246	0.025	0.025	0.025	0.025
42-44	1.000	0.587	0.216	0.197	0.927	0.624	0.136	0.240	0.009	0.009	0.009	0.009
								Sum	-0.782	-0.624	0.018	-0.176
								%	100%	80%	-2%	22%

${}_n\Delta_x^1$ = Contribution of change in probability of **birth with no obstetric intervention** to the total change in gestational length
${}_n\Delta_x^2$ = Contribution of change in probability of **birth from induced labor** to the total change in gestational length
${}_n\Delta_x^3$ = Contribution of change in probability of **birth by cesarean section** to the total change in gestational length

TABLE 2.3d: Age and delivery method decomposition of **racial gap** in expected length of gestation among **low-risk births in 2018**

	White				Black				Decomposition			
GA_x	${}_nm_x$	${}_n\mathbf{R}_x^1$	${}_n\mathbf{R}_x^2$	${}_n\mathbf{R}_x^3$	${}_nm_x$	${}_n\mathbf{R}_x^1$	${}_n\mathbf{R}_x^2$	${}_n\mathbf{R}_x^3$	${}_n\Delta_x$	${}_n\Delta_x^1$	${}_n\Delta_x^2$	${}_n\Delta_x^3$
21-23	0.000	0.429	0.000	0.571	0.000	0.600	0.200	0.200	-0.001	-0.001	0.000	0.000
24	0.000	0.462	0.077	0.462	0.000	0.333	0.333	0.333	0.000	0.000	0.000	0.000
25	0.000	0.545	0.273	0.182	0.000	0.625	0.063	0.313	-0.003	-0.002	0.000	-0.001
26	0.000	0.621	0.172	0.207	0.000	0.278	0.111	0.611	-0.002	0.000	0.000	-0.002
27	0.000	0.542	0.071	0.387	0.002	0.491	0.056	0.454	-0.014	-0.006	-0.001	-0.006
28	0.001	0.498	0.158	0.344	0.002	0.451	0.150	0.398	-0.010	-0.004	-0.001	-0.004
29	0.001	0.550	0.142	0.309	0.002	0.452	0.096	0.452	-0.010	-0.003	0.000	-0.006
30	0.001	0.560	0.153	0.287	0.003	0.512	0.132	0.356	-0.016	-0.007	-0.002	-0.006
31	0.002	0.551	0.140	0.309	0.004	0.519	0.136	0.345	-0.016	-0.008	-0.002	-0.006
32	0.003	0.563	0.159	0.278	0.005	0.515	0.157	0.327	-0.015	-0.007	-0.002	-0.006
33	0.004	0.575	0.179	0.246	0.008	0.541	0.144	0.315	-0.024	-0.012	-0.003	-0.009
34	0.008	0.551	0.223	0.226	0.014	0.534	0.204	0.263	-0.029	-0.015	-0.005	-0.009
35	0.013	0.570	0.220	0.210	0.021	0.545	0.232	0.223	-0.034	-0.017	-0.008	-0.008
36	0.027	0.578	0.246	0.176	0.040	0.569	0.214	0.217	-0.041	-0.023	-0.006	-0.012
37	0.067	0.551	0.286	0.164	0.103	0.552	0.254	0.194	-0.078	-0.044	-0.015	-0.020
38	0.152	0.618	0.239	0.142	0.227	0.612	0.232	0.156	-0.105	-0.063	-0.023	-0.019
39	0.451	0.534	0.318	0.147	0.558	0.539	0.287	0.174	-0.084	-0.047	-0.013	-0.024
40	0.823	0.522	0.351	0.127	0.876	0.490	0.336	0.174	-0.020	0.000	-0.002	-0.018
41	0.979	0.403	0.480	0.118	0.948	0.393	0.436	0.171	0.006	0.004	0.010	-0.009
42-44	0.954	0.466	0.404	0.130	0.880	0.487	0.341	0.171	0.005	0.001	0.006	-0.002
								Sum	-0.491	-0.254	-0.069	-0.168
								%	100%	52%	14%	34%

${}_n\Delta_x^1$ = Contribution of change in probability of **birth with no obstetric intervention** to the total change in gestational length
${}_n\Delta_x^2$ = Contribution of change in probability of **birth from induced labor** to the total change in gestational length
${}_n\Delta_x^3$ = Contribution of change in probability of **birth by cesarean section** to the total change in gestational length

TABLE A2.4a: Age and delivery method decomposition of **change** in expected length of gestation between 1990 and 2018 among **all White births**

	1990				2018				Decomposition			
GA_x	${}_nm_x$	${}_n\mathbf{R}_x^1$	${}_n\mathbf{R}_x^2$	${}_n\mathbf{R}_x^3$	${}_nm_x$	${}_n\mathbf{R}_x^1$	${}_n\mathbf{R}_x^2$	${}_n\mathbf{R}_x^3$	${}_n\Delta_x$	${}_n\Delta_x^1$	${}_n\Delta_x^2$	${}_n\Delta_x^3$
21-23	0.000	0.795	0.066	0.139	0.000	0.624	0.091	0.285	0.000	0.002	0.000	-0.002
24	0.001	0.727	0.031	0.242	0.001	0.380	0.072	0.548	-0.001	0.002	0.000	-0.003
25	0.001	0.584	0.051	0.365	0.001	0.373	0.047	0.580	-0.002	0.001	0.000	-0.003
26	0.001	0.574	0.033	0.393	0.001	0.337	0.082	0.581	-0.001	0.002	-0.001	-0.002
27	0.001	0.570	0.029	0.401	0.001	0.336	0.080	0.584	-0.002	0.002	-0.001	-0.003
28	0.001	0.539	0.057	0.404	0.002	0.322	0.145	0.534	-0.003	0.002	-0.002	-0.003
29	0.002	0.589	0.058	0.353	0.002	0.363	0.148	0.489	-0.002	0.003	-0.002	-0.003
30	0.002	0.594	0.059	0.346	0.002	0.376	0.172	0.452	0.000	0.005	-0.002	-0.002
31	0.003	0.626	0.066	0.307	0.003	0.387	0.181	0.432	-0.001	0.005	-0.003	-0.003
32	0.004	0.642	0.080	0.278	0.004	0.402	0.210	0.388	-0.001	0.006	-0.004	-0.004
33	0.006	0.653	0.085	0.261	0.006	0.405	0.234	0.361	-0.001	0.009	-0.006	-0.004
34	0.011	0.670	0.091	0.239	0.012	0.399	0.298	0.303	-0.007	0.012	-0.013	-0.006
35	0.019	0.685	0.097	0.218	0.019	0.428	0.293	0.279	0.000	0.019	-0.015	-0.005
36	0.033	0.683	0.111	0.206	0.036	0.436	0.323	0.241	-0.011	0.021	-0.026	-0.006
37	0.064	0.689	0.119	0.193	0.093	0.398	0.400	0.202	-0.064	0.017	-0.067	-0.014
38	0.138	0.695	0.112	0.193	0.182	0.494	0.328	0.178	-0.064	0.009	-0.065	-0.008
39	0.310	0.704	0.102	0.194	0.495	0.454	0.357	0.189	-0.159	-0.006	-0.125	-0.028
40	0.584	0.699	0.109	0.193	0.824	0.485	0.374	0.141	-0.113	0.004	-0.115	-0.002
41	0.849	0.623	0.165	0.211	0.949	0.384	0.488	0.128	-0.023	0.038	-0.073	0.013
42-44	1.000	0.580	0.204	0.216	0.935	0.426	0.425	0.149	0.009	0.024	-0.025	0.010
								Sum	-0.445	0.177	-0.544	-0.078
								%	100%	-40%	122%	18%

${}_n\Delta_x^1$ = Contribution of change in probability of birth with no obstetric intervention to the total change in gestational length

${}_n\Delta_x^2$ = Contribution of change in probability of birth from induced labor to the total change in gestational length

${}_n\Delta_x^3$ = Contribution of change in probability of birth by cesarean section to the total change in gestational length

TABLE A2.4b: Age and delivery method decomposition of **change** in expected length of gestation between 1990 and 2018 among **all Black births**

	1990				2018				Decomposition			
GA_x	${}_nm_x$	${}_n\mathbf{R}_x^1$	${}_n\mathbf{R}_x^2$	${}_n\mathbf{R}_x^3$	${}_nm_x$	${}_n\mathbf{R}_x^1$	${}_n\mathbf{R}_x^2$	${}_n\mathbf{R}_x^3$	${}_n\Delta_x$	${}_n\Delta_x^1$	${}_n\Delta_x^2$	${}_n\Delta_x^3$
21-23	0.001	0.830	0.037	0.134	0.001	0.677	0.055	0.269	0.000	-0.001	0.000	0.001
24	0.002	0.746	0.042	0.211	0.002	0.404	0.036	0.561	-0.002	0.009	0.000	-0.011
25	0.002	0.713	0.049	0.238	0.003	0.408	0.079	0.514	-0.002	0.009	-0.001	-0.010
26	0.003	0.678	0.036	0.286	0.003	0.348	0.085	0.567	0.001	0.011	-0.002	-0.009
27	0.003	0.635	0.068	0.297	0.003	0.342	0.101	0.557	-0.003	0.008	-0.001	-0.010
28	0.004	0.652	0.056	0.292	0.004	0.322	0.134	0.543	0.003	0.015	-0.003	-0.009
29	0.005	0.687	0.054	0.260	0.004	0.341	0.155	0.504	0.010	0.019	-0.003	-0.006
30	0.007	0.673	0.067	0.261	0.005	0.393	0.180	0.426	0.017	0.023	-0.004	-0.002
31	0.009	0.721	0.069	0.210	0.006	0.376	0.205	0.418	0.019	0.029	-0.005	-0.005
32	0.010	0.715	0.076	0.208	0.008	0.384	0.220	0.396	0.014	0.027	-0.006	-0.007
33	0.015	0.732	0.076	0.192	0.012	0.413	0.248	0.339	0.013	0.031	-0.011	-0.007
34	0.025	0.751	0.070	0.180	0.020	0.411	0.298	0.292	0.023	0.047	-0.019	-0.006
35	0.037	0.743	0.077	0.180	0.028	0.447	0.296	0.257	0.031	0.053	-0.020	-0.002
36	0.056	0.738	0.079	0.183	0.051	0.459	0.305	0.236	0.013	0.047	-0.030	-0.005
37	0.099	0.751	0.082	0.168	0.126	0.451	0.350	0.199	-0.050	0.033	-0.067	-0.016
38	0.200	0.751	0.074	0.175	0.247	0.537	0.297	0.167	-0.054	0.021	-0.067	-0.007
39	0.392	0.746	0.068	0.186	0.577	0.496	0.325	0.179	-0.120	0.004	-0.104	-0.020
40	0.637	0.711	0.079	0.209	0.888	0.467	0.358	0.175	-0.087	0.013	-0.093	-0.008
41	0.761	0.642	0.113	0.245	0.941	0.372	0.461	0.167	-0.031	0.024	-0.060	0.005
42-44	0.925	0.629	0.135	0.236	0.888	0.450	0.371	0.179	0.004	0.021	-0.024	0.007
								Sum	-0.199	0.445	-0.518	-0.127
								%	100%	-223%	260%	63%

${}_n\Delta_x^1$ = Contribution of change in probability of birth with no obstetric intervention to the total change in gestational length

${}_n\Delta_x^2$ = Contribution of change in probability of birth from induced labor to the total change in gestational length

${}_n\Delta_x^3$ = Contribution of change in probability of birth by cesarean section to the total change in gestational length

TABLE A2.4c: Age and Delivery method decomposition of **Racial Gap** in Expected Length of Gestation among **all births in 1990**

	White				Black				Decomposition			
GAx	${}_nm_x$	${}_n\mathbf{R}_x^1$	${}_n\mathbf{R}_x^2$	${}_n\mathbf{R}_x^3$	${}_nm_x$	${}_n\mathbf{R}_x^1$	${}_n\mathbf{R}_x^2$	${}_n\mathbf{R}_x^3$	${}_n\Delta_x$	${}_n\Delta_x^1$	${}_n\Delta_x^2$	${}_n\Delta_x^3$
21-23	0.000	0.795	0.066	0.139	0.001	0.830	0.037	0.134	-0.043	-0.036	-0.001	-0.006
24	0.001	0.727	0.031	0.242	0.002	0.746	0.042	0.211	-0.022	-0.017	-0.001	-0.004
25	0.001	0.584	0.051	0.365	0.002	0.713	0.049	0.238	-0.025	-0.019	-0.001	-0.005
26	0.001	0.574	0.033	0.393	0.003	0.678	0.036	0.286	-0.025	-0.018	-0.001	-0.006
27	0.001	0.570	0.029	0.401	0.003	0.635	0.068	0.297	-0.022	-0.015	-0.002	-0.005
28	0.001	0.539	0.057	0.404	0.004	0.652	0.056	0.292	-0.029	-0.021	-0.002	-0.007
29	0.002	0.589	0.058	0.353	0.005	0.687	0.054	0.260	-0.031	-0.023	-0.002	-0.007
30	0.002	0.594	0.059	0.346	0.007	0.673	0.067	0.261	-0.042	-0.030	-0.003	-0.009
31	0.003	0.626	0.066	0.307	0.009	0.721	0.069	0.210	-0.044	-0.034	-0.003	-0.007
32	0.004	0.642	0.080	0.278	0.010	0.715	0.076	0.208	-0.042	-0.032	-0.003	-0.007
33	0.006	0.653	0.085	0.261	0.015	0.732	0.076	0.192	-0.052	-0.041	-0.004	-0.007
34	0.011	0.670	0.091	0.239	0.025	0.751	0.070	0.180	-0.070	-0.057	-0.004	-0.009
35	0.019	0.685	0.097	0.218	0.037	0.743	0.077	0.180	-0.077	-0.062	-0.004	-0.011
36	0.033	0.683	0.111	0.206	0.056	0.738	0.079	0.183	-0.074	-0.061	-0.003	-0.011
37	0.064	0.689	0.119	0.193	0.099	0.751	0.082	0.168	-0.085	-0.073	-0.001	-0.010
38	0.138	0.695	0.112	0.193	0.200	0.751	0.074	0.175	-0.103	-0.090	0.001	-0.014
39	0.310	0.704	0.102	0.194	0.392	0.746	0.068	0.186	-0.085	-0.077	0.005	-0.013
40	0.584	0.699	0.109	0.193	0.637	0.711	0.079	0.209	-0.029	-0.025	0.007	-0.012
41	0.849	0.623	0.165	0.211	0.761	0.642	0.113	0.245	0.021	0.010	0.013	-0.002
42-44	0.990	0.580	0.204	0.216	0.925	0.629	0.135	0.236	0.009	-0.001	0.010	-0.001
								Sum	-0.870	-0.720	0.003	-0.153
								%		83%	0%	18%

${}_n\Delta_x^1$ = Contribution of change in probability of birth with no obstetric intervention to the total change in gestational length

${}_n\Delta_x^2$ = Contribution of change in probability of birth from induced labor to the total change in gestational length

${}_n\Delta_x^3$ = Contribution of change in probability of birth by cesarean section to the total change in gestational length

TABLE A2.4d: Age and Delivery method decomposition of **Racial Gap** in Expected Length of Gestation among **all births in 2018**

	White				Black					Decomposition			
GA_x	${}_nm_x$	${}_n\mathbf{R}_x^1$	${}_n\mathbf{R}_x^2$	${}_n\mathbf{R}_x^3$	${}_nm_x$	${}_n\mathbf{R}_x^1$	${}_n\mathbf{R}_x^2$	${}_n\mathbf{R}_x^3$		${}_n\Delta_x$	${}_n\Delta_x^1$	${}_n\Delta_x^2$	${}_n\Delta_x^3$
21-23	0.000	0.624	0.091	0.285	0.001	0.677	0.055	0.269		-0.043	-0.030	-0.002	-0.011
24	0.001	0.380	0.072	0.548	0.002	0.404	0.036	0.561		-0.023	-0.009	-0.001	-0.013
25	0.001	0.373	0.047	0.580	0.003	0.408	0.079	0.514		-0.025	-0.010	-0.002	-0.012
26	0.001	0.337	0.082	0.581	0.003	0.348	0.085	0.567		-0.023	-0.008	-0.002	-0.013
27	0.001	0.336	0.080	0.584	0.003	0.342	0.101	0.557		-0.023	-0.008	-0.003	-0.012
28	0.002	0.322	0.145	0.534	0.004	0.322	0.134	0.543		-0.024	-0.008	-0.003	-0.013
29	0.002	0.363	0.148	0.489	0.004	0.341	0.155	0.504		-0.019	-0.006	-0.003	-0.010
30	0.002	0.376	0.172	0.452	0.005	0.393	0.180	0.426		-0.023	-0.009	-0.004	-0.009
31	0.003	0.387	0.181	0.432	0.006	0.376	0.205	0.418		-0.023	-0.008	-0.005	-0.009
32	0.004	0.402	0.210	0.388	0.008	0.384	0.220	0.396		-0.025	-0.009	-0.006	-0.010
33	0.006	0.405	0.234	0.361	0.012	0.413	0.248	0.339		-0.034	-0.014	-0.009	-0.011
34	0.012	0.399	0.298	0.303	0.020	0.411	0.298	0.292		-0.036	-0.015	-0.011	-0.010
35	0.019	0.428	0.293	0.279	0.028	0.447	0.296	0.257		-0.038	-0.018	-0.011	-0.008
36	0.036	0.436	0.323	0.241	0.051	0.459	0.305	0.236		-0.042	-0.022	-0.011	-0.009
37	0.093	0.398	0.400	0.202	0.126	0.451	0.350	0.199		-0.068	-0.041	-0.014	-0.013
38	0.182	0.494	0.328	0.178	0.247	0.537	0.297	0.167		-0.084	-0.055	-0.018	-0.011
39	0.495	0.454	0.357	0.189	0.577	0.496	0.325	0.179		-0.058	-0.044	-0.008	-0.007
40	0.824	0.485	0.374	0.141	0.888	0.467	0.358	0.175		-0.022	-0.005	-0.003	-0.013
41	0.949	0.384	0.488	0.128	0.860	0.372	0.461	0.167		0.013	0.006	0.010	-0.003
42-44	0.935	0.426	0.425	0.149	0.888	0.450	0.371	0.179		0.003	0.000	0.004	-0.001
									Sum	-0.615	-0.314	-0.101	-0.200
									%		51%	16%	33%

${}_n\Delta_x^1$ = Contribution of change in probability of birth with no obstetric intervention to the total change in gestational length

${}_n\Delta_x^2$ = Contribution of change in probability of birth from induced labor to the total change in gestational length

${}_n\Delta_x^3$ = Contribution of change in probability of birth by cesarean section to the total change in gestational length

TABLE A2.5a: Contribution of **change** in GA-specific rates of obstetric intervention to the total change in expected gestational length among **all births** between 1990 and 2018, by race (N=1,684,114)

	White		Black	
	Wks	%	Wks	%
1990 Mean Gest. Length	39.90		39.03	
2018 Mean Gest. Length	39.46		38.83	
2018-1990 Change ($\sum {}_n\Delta_x$)	-0.44	100%	-0.20	100%
Method Decomposition ($\sum {}_n\Delta_x^i$)				
Spontaneous	0.17	-38%	0.42	-210%
Inductions	-0.55	124%	-0.52	264%
Cesareans	-0.10	23%	-0.15	77%

TABLE A2.5b: Contribution of **Black-White differences** in GA-specific rates of obstetric intervention to the total racial gap in expected gestational length among **all births**, by year (N=1,684,114)

	1990		2018	
	Wks	%	Wks	%
White Mean Gest. Length	39.90		39.46	
Black Mean Gest. Length	39.03		38.84	
Black-White Gap ($\sum {}_n\Delta_x$)	-0.87	100%	-0.61	100%
Method Decomposition ($\sum {}_n\Delta_x^i$)				
Spontaneous	-0.72	83%	-0.31	51%
Inductions	0.00	0%	-0.10	16%
Cesareans	-0.15	18%	-0.20	33%

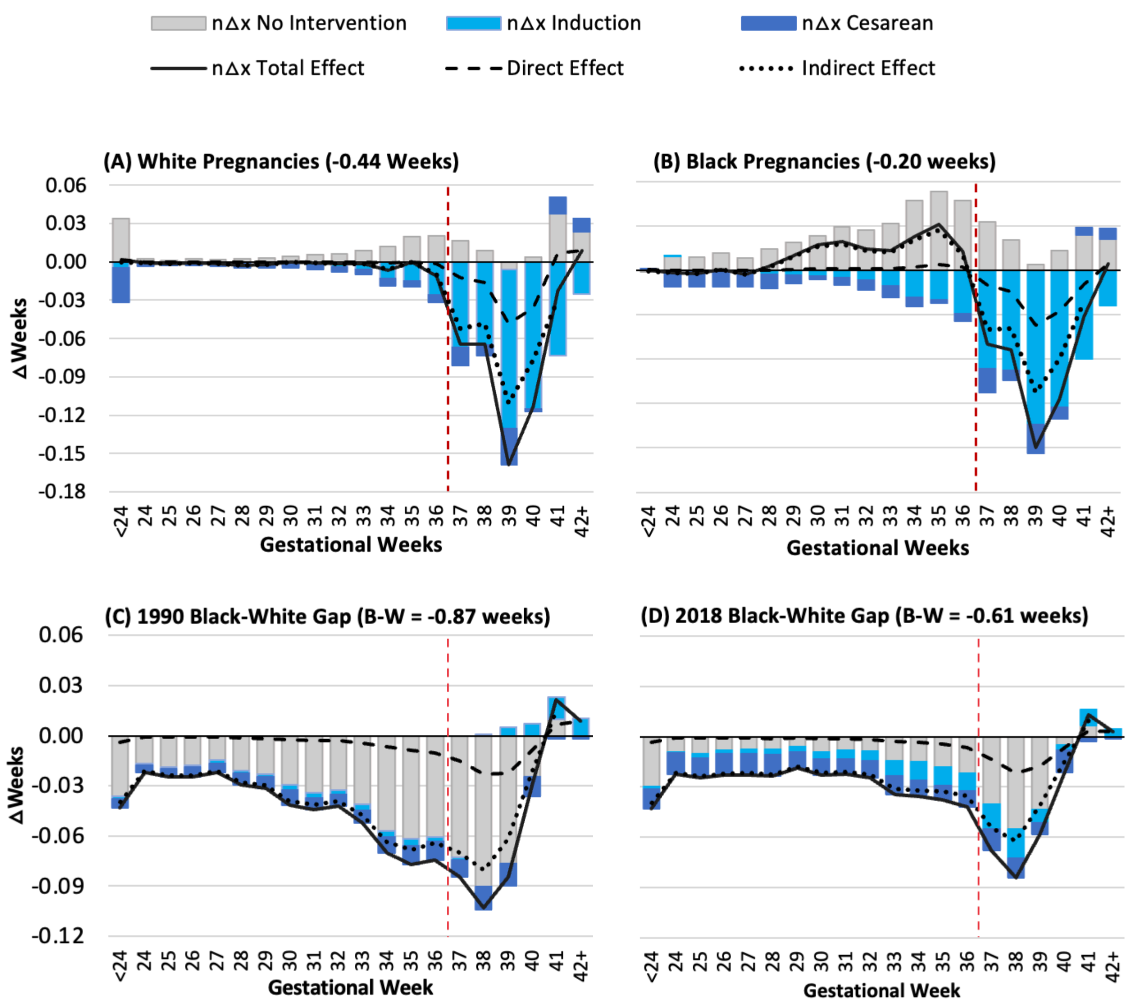
Notes: Average gestational length was calculated using multi-decrement life tables to estimate the expected remaining length of gestation among all pregnancies that reached GA=21 (e_{21}). Gestational expectancy is calculated by dividing the total number of pregnancy-weeks "lived" between GA 21-44 (T_{21}) by the total number of pregnancies that resulted in a live birth between GA 21-44 (l_{21}). The table above displays the total gestational length conditional on reaching GA=21 (e_{21} + 21) for ease of interpretation.

Method decomposition describes the contribution of group/year differences in GA- and delivery-method specific birth rates to the overall gap/change in average gestational length. This is calculated with equations 2.1-2.3 and summed across all gestational age intervals.

${}_n\Delta_x$ = Contribution of differences in the probability of birth, by any method, in gestational age group x to x+n to differences in total expected length of gestation.

${}_n\Delta_x^i$ = Contribution of differences in delivery rates by method i between gestational age x to x+n

FIGURE A2.1: Arriaga gestational age and delivery method decomposition of change in gestational length over time within race among ALL births (N=1,684,114)



Note: The above graphs depict the gestational age specific contribution made by differences in the probabilities of birth and obstetric intervention at each GA to either a lengthening (above the x-axis) or shortening (below the x-axis) of the total average gestational length over time within race. Columns to the left of the vertical red line between gestational age 36 and 37 are considered pre-term (<37 weeks) and those to the right of the vertical red line are considered term pregnancies or later.

The direct effect refers to the difference in gestational length that is attributable to differences in the probability of birth at each gestational age while the indirect effect refers to the difference in gestational length that is attributable to changes to the number of surviving pregnancies at each gestational age.

TABLE A3.1: Summary of Chapter 3 Sample Eligibility and Missing Observations, by Race

	White Births						Black Births					
	No/Not Eligible		Yes/Eligible		Missing		No/Not Eligible		Yes/Eligible		Missing	
	N	%	N	%	N	%	N	%	N	%	N	%
Inclusion Criteria												
Maternal age 15-49	1,635	<1%	2,841,720	100%	-	0%	836	<1%	633,393	100%	-	0%
Non-Hispanic	825,330	29%	1,995,846	70%	22,179	<1%	49,592	8%	579,786	91%	4,851	<1%
US-Born	538,580	19%	2,300,831	81%	3,944	<1%	117,018	18%	514,871	81%	2,340	<1%
Singleton fetus	92,079	3%	2,751,276	97%	-	0%	25,935	4%	608,294	96%	-	0%
Gest. age 21-44	21,094	<1%	2,820,443	99%	1,818	<1%	5,504	<1%	628,201	99%	524	<1%
Live birth order=1	1,760,781	62%	1,074,319	38%	8,255	<1%	406,586	64%	225,776	36%	1,867	<1%
Non-mover	748,696	26%	1,548,567	54%	546,092	19%	133,989	21%	378,267	60%	121,973	19%
Independent & Control Variables												
State felony disenfranchisement	20,513	<1%	2,814,200	99%	8,642	<1%	5,337	<1%	628,215	99%	677	<1%
State Black non-mover sample ≥25	70,652	2%	2,764,061	97%	8,642	<1%	2,850	<1%	630,702	99%	677	<1%
Maternal education	-	0%	2,810,593	99%	32,762	1%	-	0%	627,050	99%	7,179	1%
Marital status	-	0%	2,498,508	88%	344,847	12%	-	0%	605,256	95%	28,973	5%
Insurance status (e.g., Medicaid)	-	0%	2,825,746	99%	17,609	<1%	-	0%	630,702	99%	3,527	<1%
Maternal height	-	0%	2,828,823	99%	14,532	<1%	-	0%	630,516	99%	3,713	<1%
Dependent Variable												
Birth weight	-	0%	2,841,298	100%	2,057	<1%	-	0%	633,519	100%	710	<1%
Quality Check												
Birth weight for Gest. Age	568	<1%	2,839,496	100%	3,291	<1%	192	<1%	632,971	100%	1,066	<1%
Total	1,862,555	66%	410,652	14%	570,148	20%	391,845	62%	115,339	18%	127,045	20%
Chapter 3 Analytic Sample Size =	**525,991**											

Table A3.1 Notes:

All data for Chapter 3 come from 2018 birth record data from the National Center for Health Statistics. Only first singleton births to US-born non-Hispanic White and non-Hispanic Black birthing people between the ages of 15 and 49 at the time of birth are included in the analysis. Gestational ages recorded below week 21 or above week 44 are excluded as well as any birth weights that are infeasible for the recorded gestational age, which includes any birth weight that is more than 5 standard deviations above or below the gestational-age-specific mean.

“Non-mover” refers to birthing people who are living in the same state in which they themselves were born at the time of giving birth. Any observations without complete information on current state of residence or mother’s state of birth are excluded.

Two states, Maine and Vermont, have no felony disenfranchisement and are thus excluded from the analysis. Washington, D.C. did have felony disenfranchisement in 2018, but data on the disenfranchised population was not reported by the Sentencing Project and thus births from that municipality are also excluded.

States that did not have at least 25 observations from each racial group after applying exclusion criteria were also excluded. Thus the analysis does not include any observations from Hawaii, Idaho, Montana, North Dakota, New Hampshire, South Dakota, or Wyoming.

Medicaid enrollment is determined based on whether the birth was paid for with Medicaid insurance as indicated in the birth record.

The final analytic sample includes 525,991 births.

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