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Why Did Reproductive Health Improve in Washington D.C. in the 1990s? The Role of Demographic and Behavioral Changes

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Introduction

Infant health improved in Washington, DC during the 1990s at a rate unmatched nationally. Between 1991 and 2000, infant mortality fell from 20.2 to 11.9 per 1,000 live births, the lowest rate ever recorded for the District. This improvement markedly narrowed the gap between DC and national rates to 5.0 per 1,000 live births in 2000, from 11.3 in 1991 (District of Columbia State Center for Health Statistics Administration 2003). Though infant mortality fell nationally, the decline was much steeper within DC. Furthermore, the disparity in black infant mortality rates between DC and the US nearly disappeared; in 1991, the infant mortality rate among DC blacks exceeded the national black rate by 25 percent, or 4.4 per 1,000 live births. By 2001, this disadvantage had fallen to just 1.1 per 1,000 live births (District of Columbia State Center for Health Statistics Administration 2003).

Improvements in other indicators of infant health were equally impressive. Between 1990 and 2001, mean singleton birth weight climbed nearly 100 grams. The rate of low birth weight (<2500 grams) fell by more than one-third, from 14.9 to 10.2 percent. The rate of very low birth weight (<1500 grams) fell nearly as much, from 21.1 to 14.9 percent. The proportion born preterm (gestation < 37 weeks) and the proportion born full-term but low weight (intrauterine growth retarded) each fell by 34 percent, to 2.4 and 4.0 percent in 2001, respectively.[1] As with infant mortality rates, the declines in these measures helped shrink the gaps between DC and the nation, for the entire population and among blacks. Unlike the case of infant mortality, where there was improvement nationally, the gains made by DC on these infant and maternal health indicators occurred largely because there was little or no improvement at the national level and

[1] Unless otherwise stated, birth data are derived from author's tabulations of the NCHS Natality files. We included singleton births occurring in DC from 1990 through 2001 to DC residents ages 15 to 39.

very substantial improvement in Washington, DC. For instance, for the nation as a whole, the rate of low birth weight for all births rose 0.7 percentage points between 1990 and 2001, and 0.3 percentage points among blacks. As a result, the disparities between DC and national rates of low birth weight for all races and blacks each fell by nearly one-half, to 4.4 and 2.3 percentage points, respectively (Martin, et al. 2002).

Interestingly, infant health improvements in DC during this time were nearly exclusive to blacks. Thus, the black/"non-black" gap in infant and maternal health narrowed dramatically. Figure 1 demonstrates this clearly.[2] With the exception of declines in the early 1990s, rates of low birth weight and prematurity among non-blacks were flat.[3] Aggregate health indicators improved for the District, then, for two reasons. First and most importantly, infant health among blacks improved greatly (and over three-quarters of births in DC between 1990 and 2001 were to black women). Second, the share of all births to black mothers declined 12 percentage points over the period (Figure 2), and health among black infants is, on average, consistently worse than among any other racial/ethnic group.[4]

We wish to understand the reasons for these improvements in health, specifically declines in low birth weight, very low birth weight, preterm birth, and intrauterine growth retardation.

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[2] For US-DC descriptive comparisons, we include in the category "black" births to all mother who racially identify as black. Below, in graphs and regression analyses, we include only non-Hispanic blacks in the category "black." In our sample, less than two percent of blacks also identify as Hispanic.

[3] This trend is flat within non-black racial/ethnic groups as well – especially non-Hispanic whites and Hispanics.

[4] Regression analyses for a sample of all singleton births in DC confirms that the decline in the proportion of births to black women contributed modestly to improvements in infant health between 1990 and 2001. Race alone explained 28 percent of the decline in low birth weight, but only 17 percent when we also controlled for maternal age. These results are not presented but are available from the authors. Additionally, we found in earlier research that the reduction in the proportion of births to black women resulted primarily from a decline in the black population of the District, and secondarily from a decline in black fertility rates (Korenman, et al. 2004)

Because the gains in maternal and infant health occurred primarily among blacks, the focus of our analyses is mainly birth outcomes among black women. We use 1990-2001 birth certificate data from the National Center for Health Statistics (NCHS) for this purpose.

The great variation during this period in infant and maternal health, and in the black/non-black health gap, presents an opportunity to test the validity of various explanations for adverse birth outcomes and for race disparities in infant health. Lessons for public policy intended to improve infant and maternal health depend critically on understanding the causes of improved health. It is particularly important to distinguish between effects of changes in population composition and changes in maternal behaviors that are the targets of social or health policies.

The coincident timing of, on the one hand, improved infant health, and on the other, large shifts in the demographic composition of new mothers in DC away from groups traditionally considered at high risk of adverse birth outcomes, provides a logical starting point for our analysis. Family planning advocates and welfare reformers alike have emphasized the importance of reducing out-of-wedlock and/or teen births, and the proportions of births to teens and unmarried women both declined in DC in the 1990s. One provision of the 1996 Personal Responsibility and Work Opportunity Reconciliation Act (PRWORA), the Out-of-Wedlock Birth Reduction Bonus, awarded a total of $100 million per year to the five states that experienced the greatest reductions in the proportion of births that were non-marital in each of fiscal years 1999 through 2004. Washington, DC "won" an Out-of-Wedlock Birth Reduction bonus in each fiscal year in which a bonus was awarded. Congressional welfare reauthorization proposals would repeal this bonus and instead fund marriage promotion grants to states. The contribution of reductions in teen and non-marital childbearing to improvements in infant and maternal health is clearly relevant to assessing the potential benefits of these policies.

Because the District underwent significant economic recovery in the 1990s, we also consider whether infant health improved because DC attracted more low-risk residents, such as highly educated women. We test this "yuppification" hypothesis using birth certificate information on mother's education as well as her place of birth.

We examine the effects of changes in (non-demographic) maternal behaviors more directly related to infant health such as tobacco and alcohol use during pregnancy, and the adequacy of prenatal care. Several policy initiatives may have influenced these behaviors. For example, the DC Department of Health's "Healthy Residents: Year 2000" plan made reductions in smoking and increased utilization of prenatal care priorities. Additionally, net cigarette taxes rose in DC from 34 cents to $1.39 per pack between 1990 and 2001 (The Tobacco Institute 2003). There is some evidence that higher cigarette taxes affect birth outcomes by reducing prenatal smoking (Evans and Ringel 1999). Because the black/non-black gap in prenatal smoking in DC was large in 1990, some of the narrowing of the black/non-black gap in infant health could be linked to tobacco control policies.

Finally, we examine the role of more proximate determinants (rather than underlying causes) of maternal and infant health using information on 17 medical risk factors and 16 complications of labor recorded on birth certificates. Declines in these may reflect reductions in unmeasured underlying causes, and may reflect effects of prenatal care because our measure of adequacy of prenatal care is poor. For example, a decline in maternal anemia may indicate improved prenatal nutrition not captured by our prenatal care measure.

Although the proportion of births to unmarried women fell dramatically in DC, we find that the decline in births to unmarried mothers explains little to none of DC's improvement in birth outcomes during this period. We find a similar lack of explanatory power in the declines in births to teens or to women with low educational attainment. Rather, infant health improved in DC largely because health improved *within* the populations traditionally considered at high risk of adverse infant and maternal health outcomes. For example, the incidence of low birth weight fell greatly among unmarried black women as well as among black teens and those without a high school degree. We also find little evidence for the "yuppification" hypothesis, and no evidence that improvements in the adequacy of prenatal care boosted infant health in DC during the 1990s (though our measures of "yuppification" and adequacy of prenatal care are relatively crude).

The decline in tobacco use during pregnancy appears to be the single most important explanatory factor, accounting for 38 percent of the decline in low birth weight and 19 percent of the decline in preterm birth among blacks not explained by demographic changes. The decline in preterm birth, though a proximate determinant of birth weight, was as important as reduced smoking in accounting for the decline in the black rate of low birth weight. Together, demographic shifts, reduced prenatal smoking, declines in preterm deliveries, and fewer medical risk factors and complications of labor fully account for the decline in the rate of low birth weight among blacks in DC. We are unable to explain completely the decline in the black preterm birth rate.

Data and Definitions

This study analyzes the National Center for Health Statistics (NCHS) public-use Natality data files for the calendar years 1990-2001. These files contain birth certificate information for all births occurring in the US, recorded by each of the 50 States and the District of Columbia. Data are compiled in The National Vital Statistics System. In addition to year of birth and birth weight of the infant, these files include demographic information about the mother, as well as information on risky behaviors, utilization of prenatal care, and physical health.

Our sample includes only those births occurring in Washington, DC (though we are currently studying other large cities) to mothers who are DC residents. Including children born in DC to non-residents does not affect our conclusions. We further restrict the sample to singleton births to mothers ages 15 to 39, eliminating approximately 6 percent of births. Multiple births have increased over time and are more likely to be born preterm or with low or very low birth weight. This raises the concern that excluding multiple births from the analysis artificially enhances measured health improvements, but our conclusions are not affected by their exclusion (additional results are available from the authors).

Key explanatory variables

We form four mutually exclusive race/ethnicity categories for mothers: Hispanic, non-Hispanic white, non-Hispanic black, or other. Our focus is on blacks, but we conduct all of our analyses for non-blacks, for all races combined, and for each group separately. We include our results for non-blacks in the Appendix. Regression models for the sample of non-blacks include additional controls for Hispanic and "other" race/ethnicity. Since births to black women represent 76 percent of all births in our sample, results for all races combined are qualitatively similar to those for blacks, and are not presented here. In the interest of conserving space, we also do not present separate results for whites, Hispanics, and "other" races. There were a total of 10,164 births to all DC women in 1990; this number declined steadily each year, falling to 6,363 in 2001. The number of births to black women ranged from a minimum of 4,193 in 2001 to a maximum of 8,073 in 1991.

Women are asked whether they used tobacco during pregnancy and if so, how many cigarettes per day they smoked. Frequency of alcohol use is measured in drinks per week. Underreporting of smoking during pregnancy is common, but trends and population variance in smoking based on birth certificate data are consistent with those from other sources (Buescher, et al. 1993; Ventura, et al. 2003). Stigma may prevent some women from responding truthfully. Women who quit smoking or reduce alcohol consumption when they discover they are pregnant may underreport. The wording of survey questions can also greatly affect reporting accuracy (Kharrazi, et al. 1999). Underreporting will result in misclassification and is likely (though not certain) to bias downwards the estimated effects of tobacco or alcohol use on birth outcomes in a cross-section. It is unclear, however, what effect this bias would have on trends in birth outcomes. Exploratory analyses reveal that the effect of reported smoking on infant health was fairly constant over time in our data, suggesting that reporting bias did not change over time even as reported smoking during pregnancy fell sharply.[5] Additionally, the share of women for whom this information is missing did not trend over time, and we have no reason to believe that underreporting varies systematically with other maternal characteristics of interest. Therefore, we think it unlikely that measurement error in smoking and alcohol controls could account for our main findings.

Adequacy of prenatal care is measured by the Kessner Index, which classifies prenatal care as adequate, intermediate, or inadequate (Kessner, et al. 1973). We create a separate category for cases where adequacy of prenatal care is unknown. The Index is constructed from information on the timing of initiation of prenatal care and the number of visits, adjusted for

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[5] We regressed birth outcomes on smoking variables each year, separately, and found that the estimated effect of tobacco use during pregnancy was relatively constant over time. If stigma had

length of gestation. The Kessner Index has been criticized for: overemphasis on the timing of initiation of prenatal care; failure to distinguish between inadequacy of care due to late initiation from that due to an insufficient number of visits; a number of visits requirement that is too lenient at gestational ages 36 weeks or greater; and lack of guidance on dealing with missing data (Kotelchuck 1994). Kotelchuck suggests that measurement error is inherent in the Kessner Index, and that reliance on it may explain the limited empirical evidence linking prenatal care to infant health. Therefore, we attempt to minimize measurement error bias by combining intermediate and adequate into a single category, which should improve accuracy in classification (McDermott 1997). In sensitivity analyses, we also use an alternative prenatal care adequacy index proposed by Kotelchuck (1994) and find that it does not alter our conclusions.

These precautions may be insufficient to ensure reliable estimates of the effect of prenatal care on birth outcomes.[6] A relatively high proportion of birth records in our sample lack information needed to classify adequacy. Missing prenatal care information may affect our trend analyses because the quality of prenatal care information deteriorated over time (with missing adequacy rising from 4 percent of births in 1990 to 19 percent of births in 2001). We include prenatal care in some of our analyses because it is a widely studied determinant of infant health and, potentially, a key policy instrument. But we caution that we may find weak effects simply because the data are problematic.

Maternal health is reflected in 17 medical risk factors (anemia, cardiac disease, diabetes, genital herpes, hydramnios/oligohyramnios, hemoglobinopathy, chronic and pregnancy-associated hypertension, eclampsia, an incompetent cervix, renal disease, RH sensitization,

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increased such that women became more likely to underreport, then we would expect the estimated effect of smoking (and its statistical significance) to decline with time.

uterine bleeding, a previous infant born weighing 4,000 or more grams, a previous infant born preterm or small-for-gestational age, or "other"). When building our regression models, we treat having had a previous infant born preterm or small-for-gestational age separately because the literature uniformly suggests the importance of this risk factor (Goldenberg, et al. 1998; Kramer 1987; Meis, et al. 1998). We also include in some models 16 indicators of complications of labor (meconium, premature rupture of the membrane, abruptio placenta, placenta previa, other excessive bleeding, seizures during labor, prolonged labor, dysfunctional labor, breech, cephalopelvic disproportion, cord prolapse, anesthetic complications, fetal distress, or "other").

Outcomes

We use birth weight and length of gestation to construct four outcome variables. We define low birth weight (LBW) and very low birth weight (VLBW) as birth weight less than 2500 or 1500 grams, respectively. Preterm births are those with length of gestation less than 37 weeks. Intrauterine growth retardation (IUGR), sometimes called small-for-gestational-age, refers to low birth weight, but full-term (at least 37 weeks) infants. We lose 174 observations due to missing birth weight and 360 observations due to missing gestational age.

Low birth weight and short gestation are the second most important factors in infant mortality among all races, and the leading causes of death among infants born to black mothers (MacDorman and Atkinson 1999). Premature delivery, in turn, is a key predictor of low and very low birth weight.[7] Small-for-gestational-age capture aspects of low birth weight not due to prematurity. Since rates of very low birth weight and IUGR are quite low (3 and 5 percent, on

[6] Alexander, et al. 1991 showed that missing data may be an important source of bias in studies of the effects of prenatal care.

average) it is difficult to detect trends, so we focus most of our discussion on low birth weight and preterm births. Our main findings hold for all outcomes, however.

Table 1 presents summary information for these and other variables included in our regression models, for all births, and for black and non-black births separately. The gaps in infant health between blacks and non-blacks are evident and substantial. The health and social differences are well known, and require little elaboration. Education is missing/unknown for approximately 6 percent of women and adequacy of prenatal care is unknown for 13 to 15 percent. Black mothers are 66 percentage points more likely than non-black mothers to have been born in DC. We note that when preterm birth is the outcome of interest, we use a simple dummy, but when used as a predictor of low birth weight or very low birth weight, we enter separate dummies for spontaneous and non-spontaneous prematurity, where non-spontaneous preterm births include induced labors and C-sections.

Trends

In this section, we document trends among black women in explanatory factors and health outcomes. Although we noted the large demographic changes that took place in the 1990s, changes were not limited to maternal demographics. We examine the relationships between these trends and improvements in infant health in the next section.

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[7] Sixty-five percent of infants born with low birth weight and 94 percent of infants born with very low birth weight in our sample were delivered prematurely.

Demographic risk factors

DC experienced large-scale maternal demographic shifts during the 1990s. As a result, births to groups considered at high risk of adverse birth outcomes declined as a proportion of all births.

Black racial identification is one of the most prominent and least understood correlates of adverse pregnancy outcomes. Though the correlation between African-American racial identification and low socioeconomic status (SES) is strong, SES cannot fully account for the health disadvantages of black infants. High rates of low birth weight relative to whites persist within similar socioeconomic strata, and these differences cannot be explained by other measured characteristics (Geronimus 1996; Geronimus and Bound 1990). As discussed earlier, some improvements in aggregate health indicators may be attributable to the decline in the proportion of births to blacks (Figure 2), but race cannot be the primary explanatory factor because improvements in infant health occurred within race, and almost exclusively among blacks (Figure 1). As noted, we restrict our main analysis to blacks for this reason.

Non-marital births are also associated with adverse infant and maternal health outcomes. The literature offers several hypotheses for why marital status affects birth outcomes. Single mothers are less likely than married mothers to have the financial support of the baby's father. Moreover, in nearly all cases, single mothers do not benefit from the father's employer-sponsored health insurance. Lack of health coverage is associated with restricted access to care, and studies have shown that public health insurance expansions have increased utilization of prenatal care (Long and Marquis 1998). Single mothers may have less psychological day-to-day support of the father, though they may get such support from other family members. Financial hardship or lack of social support cause stress and anxiety, which may affect maternal and infant health, for example, by leading to the secretion of hormones that trigger contractions and dilation of the cervix or increased metabolic expenditure (Chomitz, et al. 1995; Nathanielsz 1995). Empirical evidence (at least weakly) links low birth weight and preterm labor to psychosocial conditions such as stress and anxiety (Goldenberg and Rouse 1998; Rutter and Quine 1990).

Out-of-wedlock pregnancies are also less likely to be planned. Awareness of and/or acknowledgement of a pregnancy tend to occur later among women with unplanned pregnancies than among those whose pregnancies are planned. They may initiate prenatal care later, on average, and unwittingly engage in unhealthy behaviors such as alcohol consumption during the early stages of pregnancy (Brown and Eisenberg 1995). For example, women with unplanned pregnancies are unable to consume the 400 micrograms of folic acid per day before conception, which is recommended to reduce low birth weight (Shore 2003). Women with unwanted pregnancies may invest too little in the infant's health and receive prenatal care late or not at all. Though studies of the effects of unintended pregnancies on birth outcomes frequently suffer from poor measurement (in part because pregnancy intention is most often measured *ex post* in surveys), they generally find that unintended pregnancies do not lead to poor infant health (see Joyce, et al. 2000).

Low maternal education is an important demographic risk factor for adverse birth outcomes. Educational attainment is highly correlated with income, and income is highly correlated with health insurance coverage and access to health care. Clearly, the disadvantages of low educational attainment may operate "indirectly," through access to resources and medical care. There may also be direct effects, such as a greater ability to understand medical advice. In economic terms, more highly educated women may be more efficient producers of prenatal and infant health (for a review, see Grossman and Kaestner 1997). To the extent that less education reflects substantial discounting of the future, women with low education may discount heavily the future health risks to their infants of current risky behaviors. (However, see Cutler and Glaeser 2005 for a new interpretation and evidence.)

Younger and older maternal ages are correlates of infant health as well. Biological aging and a higher incidence of smoking may contribute to poor pregnancy outcomes among older women. The risk for teenage mothers has many possible sources, including the tendency for teen mothers to have grown up in economically disadvantaged families. However, there is little evidence that teen age per se is a causal factor in the health disadvantages of their infants, and some evidence that among low SES women, teens have improved infant health outcomes (Geronimus 1991; 1992; Geronimus and Korenman 1992). Teen mothers are less likely to have completed their education and less likely to be married, and so risks associated with low education and single parenthood may also be relevant.

To sum up, traditional demographic risk factors for adverse birth outcomes include black racial identification, single marital status, low educational attainment, and younger and older maternal ages. DC experienced declines in nearly all of these populations during the 1990s, both overall and among blacks, which should have acted to improve infant and maternal health. Notice that changes in demographic risk factors could account for improved infant health either if demographic risk factors are "true causes" of adverse infant health outcomes, or if a "third factor," such as social disadvantage that causes both demographic risks and infant health, became less prevalent (though the interpretation and implications clearly differ).

Blacks represented 78.1 percent of all mothers in 1990 and 65.9 percent in 2001 (Figure 2). That decline was made up for nearly equally in percentage terms by increases in the shares of both whites and Hispanics (not shown). After rising from 78.5 to 83.2 percent of black births between 1990 and 1994, the proportion of black infants born to unmarried mothers fell to 79.6 percent by 2001, ending the period slightly higher than it started (Figure 3). Figure 4 shows the distribution of black births by maternal age.[8] The proportion of births to teens fell a modest 2.4 percentage points over the period. Births among women aged 30 and older, however, increased by nearly one-fifth, to over 26 percent of all births to black women. The distribution of new mothers by their educational attainment are shown in Figure 3.[9] Since the share of births to black women with less than a college education fell and the proportion to those with at least a college education rose, mothers were about one-third as likely to be college educated than not in 2001, up from one-fourth as likely in 1990.

Population changes

The demographic profile of DC changed in a number of important ways, and population changes likely played *some* role in improved birth outcomes. Net international migration of nearly 30,000 people between 1990 and 1999 (District of Columbia Office of Planning/State Data Center 1998-2002) contributed to a rise in the proportion of Hispanics, from 5.4 percent of the population in 1990 to nearly 8 percent in 2000. Blacks declined from 66.1 to 61.6 percent of the population over this period.[10] The population also became older and more educated. Among those ages 15-54, mean age rose from 33.3 in 1990 to 34.9 in 2000, and the share of those ages 25-54 with at least some college education rose 4 percentage points to 62.7 percent.[11]

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[8] This figure condenses the age groups used in the regressions described later in the paper.
[9] This figure condenses the education groups used in the regressions described later in the paper.
[10] Author's tabulations of NCHS Bridged-Race population data.
[11] Author's tabulations of the 1990 and 2000 U.S. Census 5-Percent Public Use Microdata Files (PUMS).

Healthy behaviors

Cigarette smoking during pregnancy is a key determinant of infant health, and prenatal alcohol exposure may also be important (Day, et al. 1989; England 2001; Lightwood, et al. 1999). The medical literature offers a number of ways in which tobacco and alcohol use during pregnancy may affect infant health. Prenatal alcohol exposure can cause fetal alcohol syndrome, which is characterized by fetal growth retardation and other defects (Chomitz, et al. 1995). Smoking retards fetal growth and increases the risk of placental abruption by inducing fetal hypoxia and altering the structure of the placenta (Cnattingius 1996). For these reason, prenatal smoking is more strongly associated with low birth weight than with preterm birth (Kramer 1987; U.S. Surgeon General 2001).

Prenatal care may be important for both infant and maternal health. There is a positive correlation between weight gain during pregnancy and the infant's birth weight (Kleinman 1990). A good diet can influence birth weight, fetal development, and the mother's general health. Early and regular monitoring of the fetus's development and the mother's physical health may reduce the chances of complications. As noted, however, evidence on the effect of prenatal care is mixed at best. For example, most studies of the effects of Medicaid expansions to pregnant women find that greater utilization leads to modest or no improvement in infant health (see Buescher, et al. 1991; Fiscella 1995; Joyce 1999; Levinson and Ullman 1998; Reichman and Florio 1996). Evidence from the Women, Infants, and Children (WIC) program, which combines nutritional awareness with vouchers for baby formula, milk, eggs, and other healthy foods, is similarly ambiguous (Joyce, et al. 2004; U.S. General Accounting Office 1992).

Pregnant women in DC changed their behaviors in ways that should have improved birth outcomes. Figure 5 shows that tobacco and alcohol use during pregnancy declined both in use and in frequency conditional on use. Prenatal smoking among blacks fell steeply, from 20.2 to 5.2 percent between 1990 and 2001. Black prenatal alcohol use fell 5.2 percentage points to just 1.2 percent. Though these declines were not unique to blacks (Appendix Figure A3), the decline in prenatal smoking may still account for some of the narrowing of black/non-black gaps in infant health because, in 1990, the black/non-black gap in tobacco use was large, and the non-black rate of smoking was very low. The shares of black and non-black women receiving adequate prenatal care fell during most of the 1990s and recovered only at the end of our period of study (not shown). However, since the share of women for whom we cannot determine adequacy is large and also increased over the period, it is difficult to assess the role of prenatal care.

Maternal health

Reductions in the prevalence of medical risk factors and complications during labor imply that maternal health improved in DC during the 1990s (Figure 6). Many medical conditions including hypertension, diabetes, and anemia are correlated with adverse birth outcomes. Most conditions and complications, however, are more likely markers for an underlying cause rather than root causes themselves. Still, we can estimate how *changes* in maternal health affect changes in infant health. Like declines in risky behaviors, improvements in maternal health occurred among both blacks and non-blacks (Appendix Figure A4). The reduction in medical risk factors, at least, probably cannot account for the relative reductions in adverse black birth outcomes because the black/non-black gap in their prevalence rose.

Infant health

Figure 7 documents trends in four indicators of infant health – low birth weight, preterm birth, very low birth weight, and intrauterine growth retardation – among black women. Rates of all adverse outcomes declined significantly between 1990 and 2001. The likelihood of preterm delivery declined from 23.6 to 18.3 percent. The rate of low birth weight fell from 17.1 to 12.9 percent – 2.3 percentage points greater than the national rate of low birth weight among blacks and 5 percentage points higher than the aggregate US rate of low birth weight in 2001 (Martin, et al. 2002). Intrauterine growth retardation and very low birth weight fell 0.02 and 0.01 percentage points, respectively. Though small in absolute size, these changes represent 29 and 25 percent declines.

Although demographic shifts contributed to improved birth outcomes, improvements were largely driven by health gains within high-risk groups. The greatest gains among blacks occurred to unmarried, less educated, and teenage mothers.[12] Figures 8 and 9 show this clearly. The rate of low birth weight increased between 1990 and 2001 among black married women, but declined steeply among their unmarried counterparts (Figure 8). Similarly, the rate of low birth weight among black women with at least a college education fell modestly, but declined 25 percent among those with less than a college education. The differences are less stark when describing trends in the rate of preterm birth, but the general conclusions remain.

Older women experience worsened birth outcomes by 2001 (Figure 9). The likelihood of low birth weight increased 12.8 percent among black women aged 35 years and older. The probability of preterm delivery among this group rose 16 percent. On the other hand, declines in

[12] This is also true among all races combined.

the rates of low birth weight among all other age groups, including teens, ranged from 24 to 35 percent, and declines in the rates of preterm birth were nearly as great.

Since improvements in health occurred within high-risk demographic groups, demographic changes clearly cannot fully explain gains in black infant health. In the next section, we use regression analysis to estimate the contributions of demographic characteristics and other factors to changes in measured infant health among blacks.

Regression Analyses

We estimate linear probability models with robust standard errors (to correct for heteroscedasticty) in which the dependent variable is one of our four birth outcomes. Covariates include a linear trend and demographic and other characteristics of the mother. Graphical analysis suggests a linear time trend is appropriate (e.g., Figure 7). We build the model incrementally, examining how the coefficient of the time trend changes as we add covariates. These coefficients are shown in Table 2 for each of our models. Coefficients reported in all tables are inflated by a factor of 100, so the coefficient of the trend represents the average yearly percentage point change in the outcome. Multiplying this by twelve yields the percentage point change over the entire period studied. Though we present results for four outcomes, we focus on low birth weight and preterm births among black women. (We present results for all singleton to non-black women in the Appendix.)

Demographic risk factors

Model 1 of Table 2 shows the tremendous declines in low birth weight and preterm birth, adjusted only for the infant's sex. The rate of low birth weight declined 0.38 percentage points per year or 4.6 percentage points over 12 years. The rate of preterm birth declined 0.5 percentage points per year or 6.1 percentage points over 12 years.

Models 2-5 reveal that the decline in black births to unmarried, younger, and less-educated mothers explain at most 13 percent of the estimated reduction in the black rate of low birth weight between 1990 and 2001, whether these characteristics are entered into the regression alone or in combination. Black racial identification alone explains about a quarter of the downward trend in low birth weight in the full sample (results not shown), but marital status, maternal age, and maternal education have little, if any, additional effect on the decline in the rate of low birth weight above and beyond that captured by race. These demographic characteristics explain even less of the reduction in the preterm rate.

Model 6 adds controls for parity and mother's place of birth. First births declined as a share of births to black women. First pregnancies may be more stressful, or women who have higher order births may be selected for good maternal health. On the other hand, first-time mothers are less likely to deliver prematurely, which raises birth weight. As noted, mother's place of birth is included to test the hypothesis that improvements in infant health are associated with yuppification of DC. If women of higher SES from outside DC became increasingly willing to raise their children in the District during the 1990s, then mother's place of birth outside DC might proxy for these changes. These adjustments have no impact on the decline in the rate of preterm birth and little effect on trends in other outcomes.[13]

In Model 7 we add dummies for spontaneous and non-spontaneous premature delivery to the low birth weight and very low birth weight regressions. Low and very low birth weight have

[13] Mother's place of birth may not have any effect in the sample of blacks because the shares of black mothers born in DC or in nearby states changed little. It has a modest effect on some outcomes in the sample of non-blacks among whom there was more variation in place of birth.

two compositional sources – a reduction in prematurity and improved gestational growth. The former is thought to be less responsive to intervention than the latter. We differentiate between spontaneous and non-spontaneous preterm birth because the health of infants born prematurely due to obstetric interventions may differ from those born "naturally" premature. Obstetricians sometimes induce premature delivery in order to minimize negative health outcomes for the infant and/or mother (Goldenberg and Rouse 1998). Furthermore, there is evidence that risk factors differ for spontaneous and non-spontaneous preterm births (Meis, et al. 1998).

Of course, these are proximate rather than root causes. The coefficient on spontaneous preterm birth may suffer from omitted variable bias as a result. Additionally, non-spontaneous prematurity may be endogenous if the decline in the rate of preterm delivery led to greater use of induced labor at longer gestations. For these reasons, we do not interpret the coefficients on these variables, but only consider how their inclusion in the model affects the trend coefficient. Compared with demographic risk factors, preterm delivery is quite important. The decline in preterm births explains nearly 40 percent of the "unexplained" trend in low birth weight (that portion not explained by maternal demographics, pregnancy history, and mother's place of birth).

A full set of coefficients for Model 6 are shown in Table 3. These results confirm that black women who are married or have at least some college education are significantly less likely to bear low birth weight, preterm, very low birth weight, or small-for-gestational-age infants. First pregnancies are less likely to result in premature delivery, but more likely to result in a low birth weight, very low birth weight, or small-for-gestational-age infant. Women born in states other than Maryland, Delaware Virginia, or West Virginia or outside the US are at lower risk of adverse birth outcomes relative to those born in DC. The insignificance of the coefficient for mother's born in MD, DE, VA, or WV relative to those born in DC suggests that any relevant differences between those born in DC and migrants from nearby states are captured by demographics.

An interesting result is that, contrary to the hypothesis that young age is disadvantageous for infant health, black teenagers are at lower risk of adverse pregnancy outcomes than any other age group. Furthermore, risk rises monotonically with age, and this result is unique to blacks (see Table A2 in the Appendix for non-black results). This is consistent with the weathering hypothesis proposed by Geronimus, in which the impact of socioeconomic disadvantage is cumulative and produces a positive age-risk profile among low SES black mothers (Geronimus 1986; 1996). This finding is robust to all model specifications predicting low birth weight, including the simple model where we control only for infant's sex and maternal age, and has a striking implication. Improvements in black infant health would have been even greater had maternal age not risen. Delayed childbearing among blacks appears to have worsened infant health and dampened the improvements in birth outcomes. We find weaker evidence of weathering in our models of premature delivery. Risk of preterm birth rises with age among older women, but the age-risk profile is relatively flat among women aged 15-24.

In a study of birth outcomes in the 1980s and 1990s, Almond and Chay conclude that weathering effects may be an artifact of better health among younger cohorts (Almond and Chay 2003). Evidence of weathering disappears in their analyses when they control for birth cohort of mother. In results not shown here, we find that including cohort dummies (and dropping the time trend) eliminates the weathering effect only in models that do not also include controls for education. In these models without education controls, within birth cohorts of mothers, black teens are more likely to bear unhealthy infants than those ages 20-24. One interpretation of this finding is that if delayed child bearing increases education, then it may improve infant health. On the other hand, if delaying childbearing merely delays age at birth but does not result in increased education, it may harm infant and maternal health. One difficulty with this analysis, however, is our inability to estimate age, period, and cohort effects simultaneously. Which cohort model is correct, then – the model that includes or excludes education controls? If we wish to estimate the effects of age at birth, and if delayed childbearing is responsible for increasing education across cohorts, then it is inappropriate to control for education. However, if education is increasing across cohorts for reasons other than fertility delay (which seems likely), then we should control for education. The conclusion is uncertain at this point, though we are continuing to explore these issues.[14]

Behavioral and maternal health risk factors

We turn next to the role of non-demographic maternal behaviors, medical conditions and complications of labor. Model 8 adds controls for tobacco and alcohol use during pregnancy: dummies for usage as well as indicators for the number of cigarettes smoked per day and the number of drinks consumed per week (Sprauve, et al. 1999). In other analyses (not shown), we confirm that including frequency of use covariates reduces the estimated effects of tobacco or alcohol use on infant health, but does not alter our regression-adjusted trends in birth outcomes.

[14] Almond and Chay also use NCHS Natality data and control for education, but their study differs from ours in a number of ways that could explain the different results. They include births in all 50 states and the District of Columbia, as well as births in the 1980s. Their sample is limited to births to mothers born during the 1960s. Mothers in our sample were born over a longer time horizon – from the mid-1950s to the early 1980s. Finally, their estimation approach differs from ours in that they control simultaneously for mother's age, birth cohort, and survey year. We are exploring these issues in ongoing work.

Models 8-10 demonstrate the importance of tobacco use as an explanation for improved infant health. The decline in prenatal tobacco use explains nearly as much of the trend in the low birth weight as the reduction in pre-term delivery (Models 7 vs. 8). The reduction in prenatal smoking accounts for 38 percent of the decline in the rate of low birth weight and 19 percent of the decline in the rate of prematurity not already explained by demographics, pregnancy history, and mother's place of birth (Model 8). Alcohol use during pregnancy has little effect on the trend in low birth weight or preterm birth once we control for smoking. Adequacy of prenatal care has no additional effect on the decline in the rate of low birth weight and only minor additional impact on the reduction in the rate of prematurity beyond that captured by prenatal tobacco use, though as we noted earlier, measurement error in prenatal care may be large.

Model 11 adds dummies for spontaneous and non-spontaneous prematurity to the low birth weight and very low birth weight regressions. Though Models 6 and 7 already reveal the importance of prematurity, we add it here to show that the decline in preterm delivery has significant explanatory power above and beyond prenatal smoking. More than half of the trend in low birth weight not already explained by the covariates in Model 10 can be attributed to the reduction in prematurity.

The annual decline in low birth weight falls another 0.03 percentage points once we control for history of preterm or small-for-gestational age births (Model 12a). The regression-adjusted reduction in low birth weight is only 0.07 percentage points per year, and is just significant at the 5 percent level. Controlling for history of poor infant health reduces the estimated trend in preterm birth to 0.35 percentage points per year (Model 12b).

Models 13 and 14 consider how improvements in medical conditions related to maternal health and reductions in complications during labor may have contributed to improved infant health among blacks. We add to our specifications 16 dummies for each medical risk factor and 16 dummies for each complication of labor. These covariates may be symptoms of underlying causes of poor maternal and infant health rather than direct causes. The estimated change in low birth weight, once we control for maternal health and/or complications of labor, is statistically zero. Together, they reduce the decline in the rate of prematurity to 0.23 percentage points per year, which is still significantly different from zero but 55 percent lower than the estimated change in the preterm birth rate adjusted only for infant's sex.

Table 4 presents coefficients from Model 10 for tobacco and alcohol use during pregnancy and adequacy of prenatal care. Prenatal smoking has large, positive, and significant effects on all outcomes. Tobacco use during pregnancy increases the likelihood of low birth weight among blacks by 5.7 percentage points, and this probability increases by 0.3 percentage points for every additional cigarette smoked. Though alcohol use and prenatal care do not contribute to trends in infant health beyond that already explained by smoking, they do affect the probability of adverse outcomes. Alcohol use increases the likelihood of low birth weight by 6.4 percentage points, and this probability increases by 1.3 percentage points for every additional drink consumed per week. Adequate prenatal care is associated with better infant health and has the largest effect on the probability of prematurity. Results not shown suggest that some of the effects of prenatal care on low birth weight operate through a reduction in prematurity.[15] The magnitudes of the estimated effects of prenatal care on all four outcomes are strikingly similar in the sample of blacks and the sample of non-blacks (See Table A3 in the Appendix).

In summary, we are able to explain fully the decline in the rate of low birth weight among blacks over the period 1990-2001. The key factors are reductions in prenatal smoking and premature deliveries (though we regard prematurity as a proximate determinant rather than an underlying cause). We can explain up to 55 percent of the decline in preterm births. Again, prenatal smoking is the most important determinant. Reductions in medical risk factors and complications of labor are also associated with declines in the rates of low birth weight and preterm birth. Shifts in demographic risk factors, however, contribute only modestly.

Discussion

This study attempts to explain the dramatic improvements in infant health among blacks in DC between 1990 and 2001. Coincident maternal demographic shifts away from women considered at high risk for adverse birth outcomes suggests one avenue of exploration. The contributions of the declines in births to unmarried mothers and teen mothers are particularly relevant to the current debate over welfare reform and the administration's more general emphasis on marriage. The 1990s were also a time in which smoking was discouraged and prenatal care encouraged.

Although black, unmarried, less educated, and younger or older women have elevated probabilities of adverse pregnancy outcomes, reductions in the proportions of mothers with these characteristics explain only a modest share of infant health improvements in DC during the 1990s. The reason is that most of the improvements in birth outcomes resulted from improvements within the populations at highest risk. Delayed childbearing in this period may even have worsened black infant health. Although out-of-wedlock childbearing may have negative consequences for infant health (Eberstadt 1994a; b), the substantial decline in proportion of black births to unmarried mothers explains little to none of the improvement in

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[15] The estimated effect of adequate prenatal care on low birth weight falls after we control for

birth outcomes in Washington, DC during this period. Increased utilization of prenatal care also explains little of the improvement in black infant health, though that may be because it is poorly measured in our data.

Health gains were due primarily to a reduction in smoking during pregnancy. A steep fall in prematurity, though not an underlying cause, explains a substantial part of the decline in low birth weight as well. Although we can fully account for the reduction in low birth weight among blacks in DC during the 1990s there remains a substantial unexplained portion of the decline in preterm birth.

These results have two major implications. First, they suggest that interventions or improved knowledge about the health hazards of smoking were successful in improving the health of black mothers and infants. However, smoking during pregnancy is now very low – only 3.6 percent of pregnant women smoked in 2001. The non-black experience of a decline in tobacco use from an already low rate and relatively flat trend in infant health is suggestive of the limitations of future reductions in smoking for improving the health of black infants.

Second, based on our findings, it would be inappropriate to attribute improvements in infant health outcomes to welfare reform-driven reductions in out-of-wedlock childbearing or other demographic shifts. Despite a substantial decline in the proportion of births to unmarried women that resulted in the awarding of six consecutive "Illegitimacy Bonuses" to DC, improvements in infant health took place largely among unmarried mothers. However, there is very little evidence that welfare reform was responsible for marriage or fertility changes in the 1990s. Therefore, if welfare reform were responsible for improvements in infant health, it would

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preterm delivery.

have to have been through channels other than marriage or fertility behavior (e.g., perhaps through increased employment or decreased poverty).

We are currently exploring several additional hypotheses. First, we are extending our analysis to other large cities, many with substantial black populations. Out-migration of high-risk women to suburbs could have reduced measured low birth weight in central cities without an improvement in infant health for the entire metropolitan region. Our preliminary analyses find evidence that gaps in infant health between central cities and their suburbs narrowed in Atlanta, Baltimore, Chicago, Detroit, Los Angeles, New York City, Philadelphia, and DC, especially among blacks. The fact that the concentration of poverty declined in central cities during the 1990s but increased in inner-ring suburbs suggests that selective out-migration may have occurred (Jargowsky 2003). One recent study of the decline in low birth weight in New York City during the 1990s offers another hypothesis. These researchers conclude that NYC improvements in infant health reflect a regression to the mean following the cocaine epidemic of the 1980s (Joyce, et al. 2005). Though NCHS birth certificate data do not report illegal drug use, we are currently extending our analysis back through the 1980s.

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Figure 1. Low birth weight or preterm birth by race, 1990-2001.

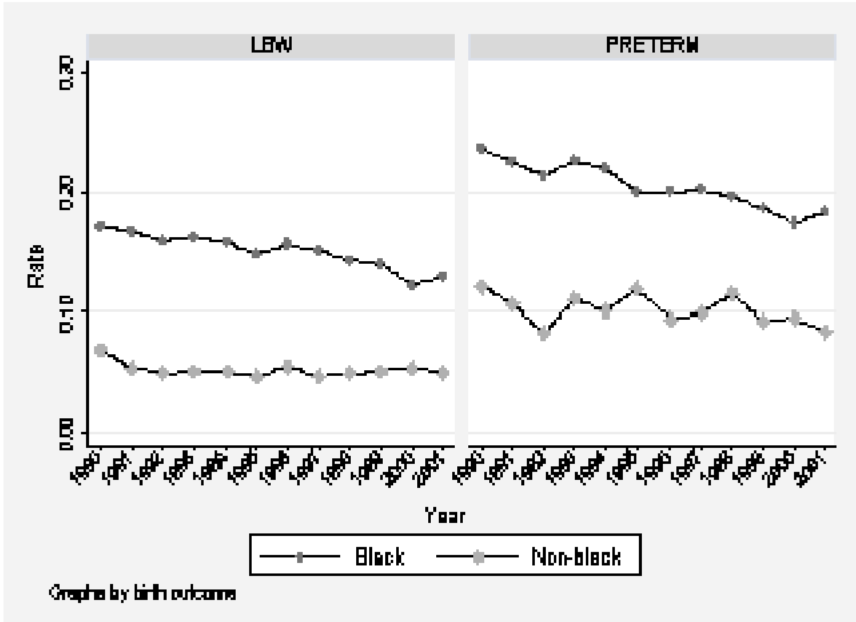

Figure 2. Distribution of births by race, 1990-2001.

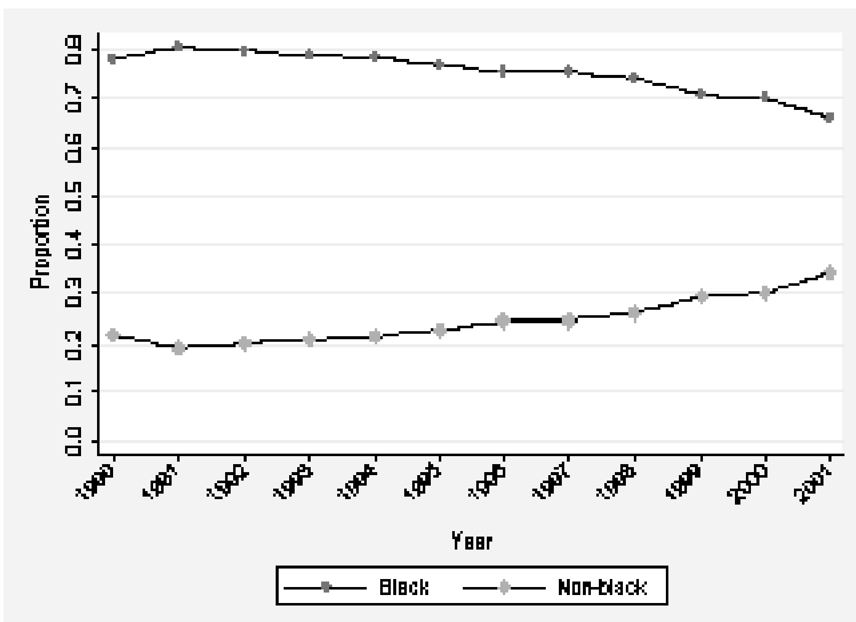

Figure 3. Distribution of births to black women by marital status and maternal education, 1990-2001.

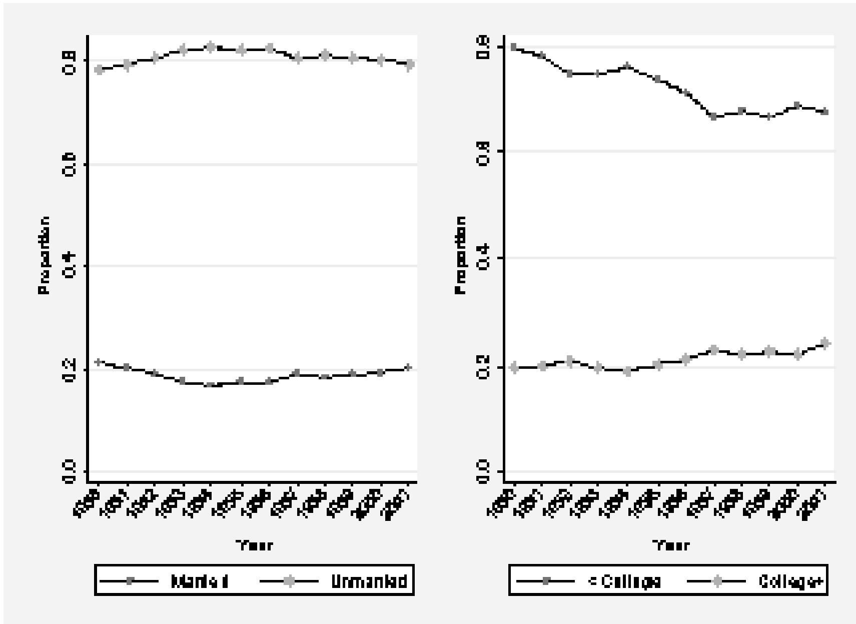

Figure 4. Distribution of births to black women by maternal age, 1990-2001.

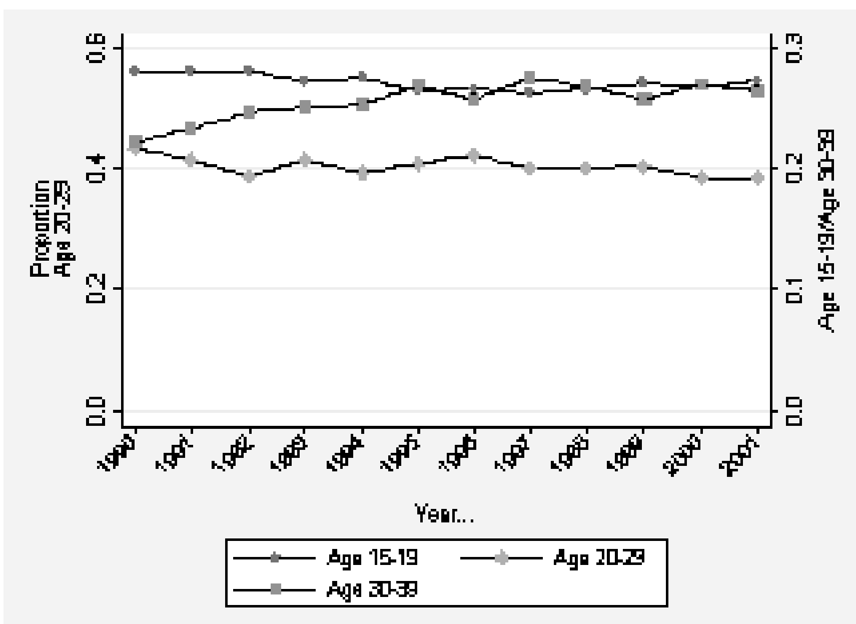

Figure 5. Trends in prenatal tobacco and alcohol use among black women, 1990-2001.

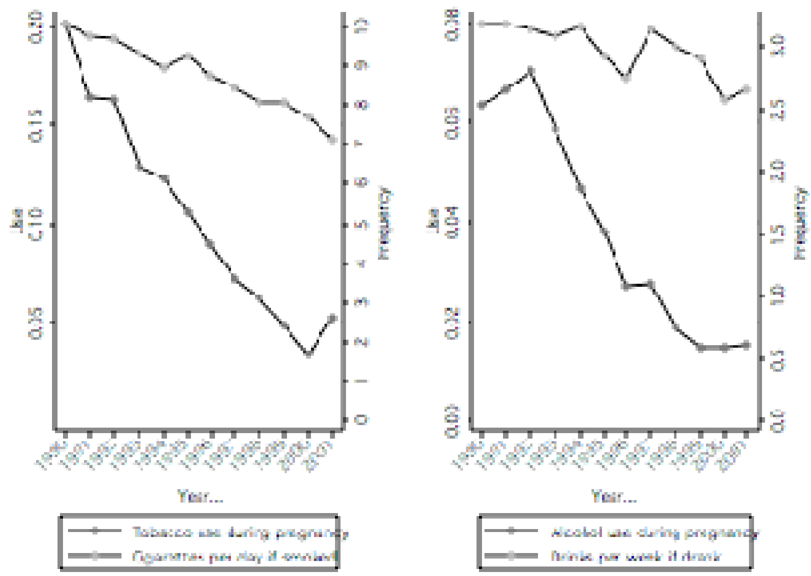

Figure 6. Trends in maternal health among black women, 1990-2001.

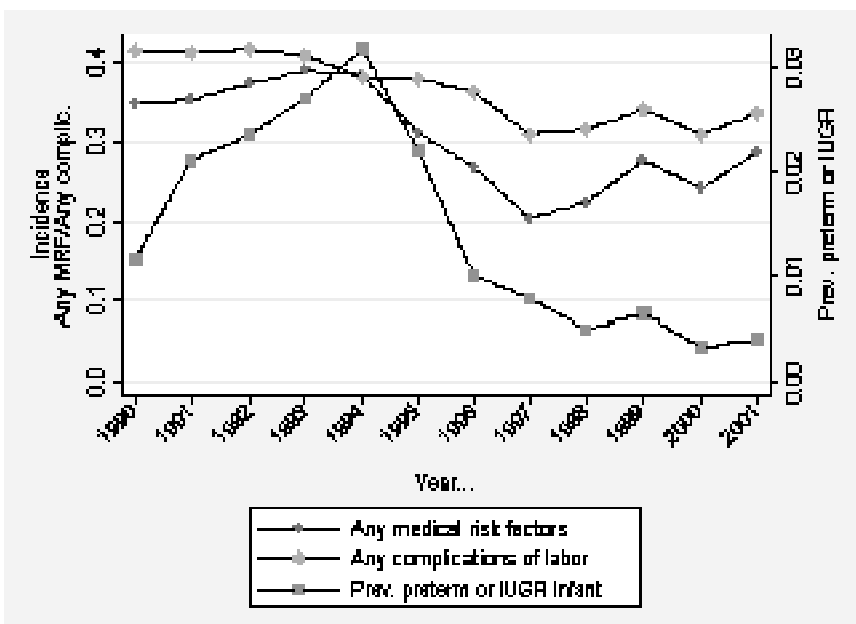

Figure 7. Trends in low birth weight, preterm birth, very low birth weight, and intrauterine growth retardation among black infants, 1990-2001.

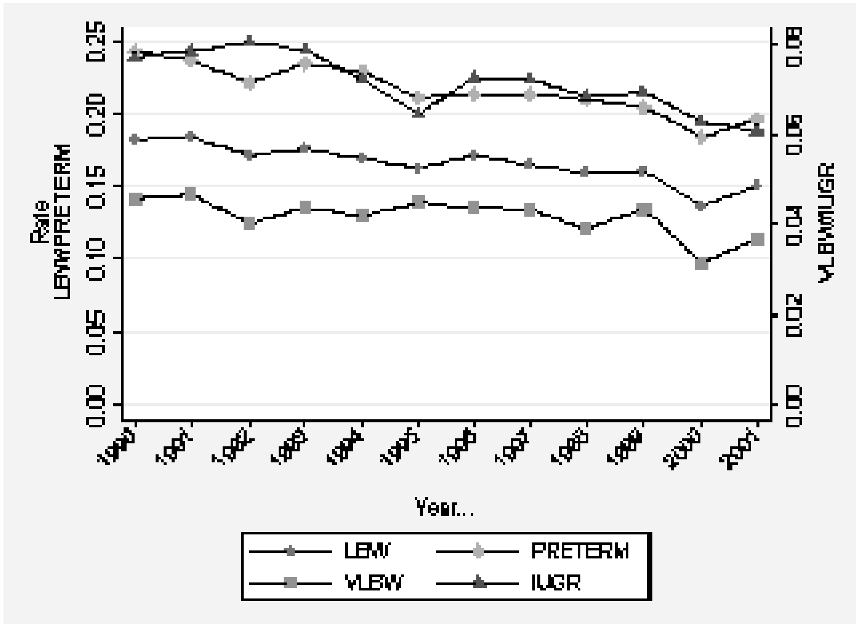

Figure 8. Trends in low birth weight or preterm birth among black mothers by marital status and maternal education, 1990-2001.

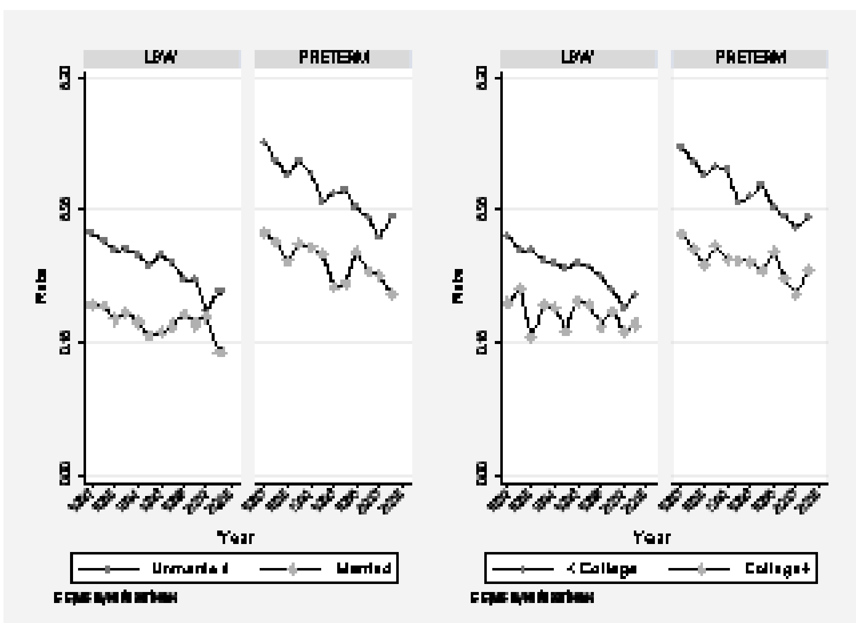

Figure 9. Trends in low birth weight or preterm birth among black mothers by maternal age, 1990-2001.

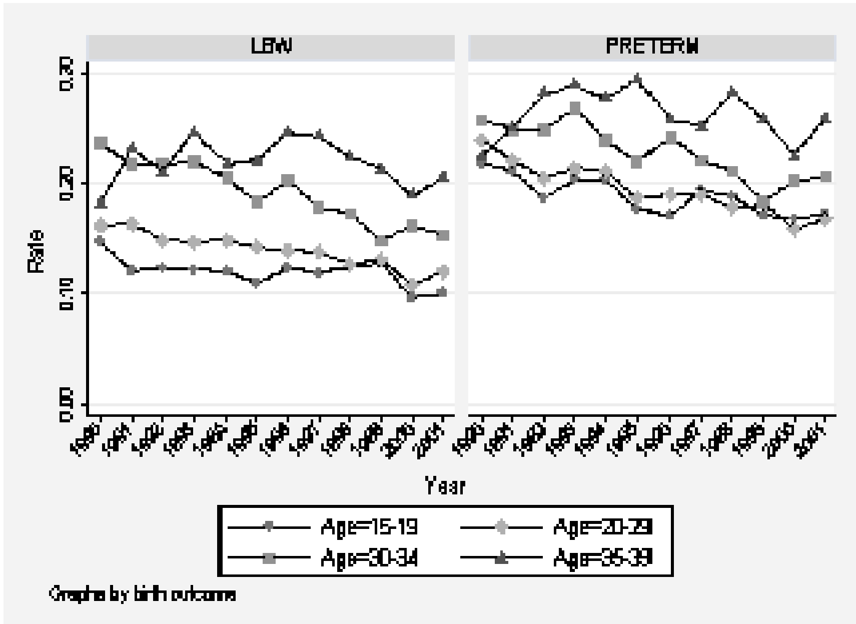

Table 1. Summary statistics for singleton births in Washington DC, 1990-2001 (percents, unless indicated)

	All	Blacks	Non-blacks
Number of records per year	*7,823*	*5,948*	*1,876*
Outcomes			
Low birth weight	12.9	15.3	5.3
Preterm	18.3	20.9	10.2
Very low birth weight	3.1	3.8	1.0
Intrauterine growth retardation	5.5	6.7	2.3
Covariates			
Female infant	49.2	49.5	48.5
Non-Hispanic black	76.0	100.0	0.0
Married	31.3	19.0	70.2
Maternal age			
15-19	17.1	20.3	6.9
20-24	27.2	30.4	17.0
25-29	23.8	24.1	22.9
30-34	20.7	17.0	32.3
35-39	11.3	8.3	20.8
Maternal educational attainment			
Less than high school	29.0	29.4	27.7
High school	36.5	43.6	14.0
College or more	28.5	20.9	52.4
Unknown	6.0	6.0	5.9
Parity			
0	38.3	34.5	50.4
1+	61.7	65.5	49.6
Unknown	0.0	0.0	0.0
Mother's place of birth			
DC	58.2	74.0	7.9
DE/MD/VA/WV	5.3	5.9	3.4
Other state	16.7	11.9	31.8
Foreign	19.9	8.2	56.9

(Table continues on next page)

Table 1 (cont'd). Summary statistics for singleton births in Washington DC, 1990-2001 (percents, unless indicated)

	All	Blacks	Non-blacks
Tobacco use during pregnancy	9.2	11.5	1.9
No. cigarettes per day conditional on use	9.3	9.3	8.6
Alcohol use during pregnancy	4.0	4.3	3.1
No. drinks per week conditional on use	2.8	3.1	1.7
Prenatal care			
Inadequate	17.7	20.3	9.3
Adequate	67.9	64.7	77.8
Unknown	14.5	14.9	12.9
Pregnancy term			
Full-term birth	81.7	79.1	89.8
Spontaneous preterm birth	12.9	14.7	7.1
Nonspontaneous preterm birth	5.5	6.2	3.1
Previous preterm or IUGR birth	1.3	1.6	0.4
Any medical risk factor	30.5	32.5	24.1
Any complications of labor	36.1	37.4	32.0

Table 2. Regression-adjusted trends in birth outcomes among blacks in DC, 1990-2001

Coefficients of linear time trend x 100 [robust standard errors]

Panel A					
		Outcome			
		LBW		PRETERM	
Model	**Covariates**	*Coefficient*	*SE*	*Coefficient*	*SE*
1	Female	-0.38*	[0.04]	-0.51*	[0.04]
2	Female, Married	-0.38*	[0.04]	-0.51*	[0.04]
3	Female, Age (4)	-0.41*	[0.04]	-0.53*	[0.04]
4	Female, Married, Age (4)	-0.43*	[0.04]	-0.55*	[0.04]
5	Female, Married, Age (4), Education (3)	-0.43*	[0.04]	-0.52*	[0.04]
6	Female, Married, Age (4), Education (3), Parity (2), Mother's place of birth (3)	-0.42*	[0.04]	-0.52*	[0.04]
7	6 + Preterm (2)	-0.23*	[0.03]		
8	6 + Tobacco (2)	-0.26*	[0.04]	-0.42*	[0.04]
9	6 + Tobacco (2), Alcohol (2)	-0.22*	[0.04]	-0.40*	[0.04]
10	6 + Tobacco (2), Alcohol (2), Prenatal care (2)	-0.22*	[0.04]	-0.38*	[0.05]
11	6 + Tobacco (2), Alcohol (2), Prenatal care (2), Preterm (2)	-0.08*	[0.04]		
12a	6 + Tobacco (2), Alcohol (2), Prenatal care (2), Preterm (2), Previous preterm or IUGR	-0.06	[0.04]		
12b	6 + Tobacco (2), Alcohol (2), Prenatal care (2), Previous preterm or IUGR			-0.35*	[0.05]
13	12 + Medical risk factors (16)	-0.04	[0.04]	-0.31*	[0.05]
14	12 + Medical risk factors (16), Complications of labor (16)	0.03	[0.04]	-0.23*	[0.05]

Notes:

* p<0.5

The sample size is approximately 71,000 live singleton births.

The number in parentheses following a variable name is the number of included dummy variables. See Table 1 for categories

(Table continued on next page)

Table 2 (cont'd). Regression-adjusted trends in birth outcomes among blacks in DC, 1990-2001

Coefficients of linear time trend x 100 [robust standard errors]

	Panel B				
		Outcome			
		VLBW		IUGR	
Model	**Covariates**	*Coefficient*	*SE*	*Coefficient*	*SE*
1	Female	-0.09*	[0.02]	-0.16*	[0.03]
2	Female, Married	-0.10*	[0.02]	-0.17*	[0.03]
3	Female, Age (4)	-0.10*	[0.02]	-0.18*	[0.03]
4	Female, Married, Age (4)	-0.10*	[0.02]	-0.19*	[0.03]
5	Female, Married, Age (4), Education (3)	-0.12*	[0.02]	-0.17*	[0.03]
6	Female, Married, Age (4), Education (3), Parity (2), Mother's place of birth (3)	-0.13*	[0.02]	-0.16*	[0.03]
7	6 + Preterm (2)	-0.05*	[0.02]		
8	6 + Tobacco (2)	-0.10*	[0.02]	-0.07*	[0.03]
9	6 + Tobacco (2), Alcohol (2)	-0.09*	[0.02]	-0.04	[0.03]
10	6 + Tobacco (2), Alcohol (2), Prenatal care (2)	-0.10*	[0.02]	-0.01	[0.03]
11	6 + Tobacco (2), Alcohol (2), Prenatal care (2), Preterm (2)	-0.05*	[0.02]		
12a	6 + Tobacco (2), Alcohol (2), Prenatal care (2), Preterm (2), Previous preterm or IUGR	-0.04*	[0.02]		
12b	6 + Tobacco (2), Alcohol (2), Prenatal care (2), Previous preterm or IUGR			0.00	[0.03]
13	12 + Medical risk factors (16)	-0.04	[0.02]	0.00	[0.03]
14	12 + Medical risk factors (16), Complications of labor (16)	0.01	[0.02]	0.01	[0.03]

Notes:
* p<0.5
IUGR: Intrauterine Growth Retarded (LBW among full-term births). Preterm births are excluded from the IUGR analyses.
The sample size is approximately 71,000 singleton births for VLBW and 56,000 for IUGR.

Table 3. Regression estimates of demographic effects on infant health outcomes, births to black women in Washington DC 1990-2001 (Model 6)

Coefficients X 100 [robust standard errors]

	Outcome			
	LBW	PRETERM	VLBW	IUGR
Year	-0.42*	-0.52*	-0.13*	-0.16*
	[0.04]	[0.04]	[0.02]	[0.03]
Female	2.71*	-0.54	0.02	2.38*
	[0.27]	[0.30]	[0.14]	[0.21]
Married	-6.09*	-6.25*	-1.31*	-3.88*
	[0.37]	[0.41]	[0.20]	[0.27]
Age = 20-24	2.77*	0.55	1.09*	1.51*
	[0.39]	[0.46]	[0.20]	[0.30]
Age = 25 -29	7.87*	4.59*	2.48*	4.35*
	[0.46]	[0.53]	[0.25]	[0.36]
Age = 30-34	12.44*	7.34*	3.15*	7.33*
	[0.53]	[0.59]	[0.28]	[0.44]
Age = 34-39	15.56*	11.20*	3.94*	8.94*
	[0.67]	[0.74]	[0.37]	[0.57]
Education = High school	-2.24*	-2.53*	-0.28	-1.90*
	[0.35]	[0.39]	[0.18]	[0.29]
Education = College or more	-5.86*	-6.58*	-1.10*	-4.09*
	[0.44]	[0.49]	[0.23]	[0.35]
Parity = 1 or more	-0.69*	3.20*	-0.75*	-0.64*
	[0.31]	[0.35]	[0.17]	[0.23]
Mother's place of birth = DE/MD/VA/WV	-0.04	-0.10	-0.29	0.34
	[0.58]	[0.65]	[0.30]	[0.47]
Mother's place of birth = Other State	-1.45*	-1.79*	-0.42	-0.39
	[0.42]	[0.47]	[0.22]	[0.33]
Mother's place of birth = Foreign	-3.89*	-2.35*	0.47	-2.64*
	[0.47]	[0.55]	[0.29]	[0.33]
Number of births	71,250	71,149	71,250	56,257

Notes:
* p<0.5
Reference categories are: age 15-19, education less than high school, parity 0, and mother's place of birth Washington DC. Models also include dummies for unknown education and unknown parity.

Table 4. Regression estimates of smoking, alcohol, and adequacy of prenatal care on infant health outcomes, births to black women in Washington DC 1990-2001 (Model 10)

Coefficients X 100 [robust standard errors]

	Outcome			
	LBW	PRETERM	VLBW	IUGR
Tobacco use during pregnancy	5.66*	4.58*	0.92*	3.18*
	[0.89]	[0.94]	[0.46]	[0.83]
Cigarettes per day	0.26*	-0.01	0.00	0.27*
	[0.08]	[0.08]	[0.04]	[0.08]
Alcohol use during pregnancy	6.40*	5.44	1.87	4.31
	[2.74]	[2.83]	[1.51]	[2.73]
Drinks per week	1.32	0.38	0.31	0.96
	[0.84]	[0.86]	[0.46]	[0.86]
Prenatal care = Adequate	-7.20*	-7.08*	-1.85*	-4.11*
	[0.38]	[0.42]	[0.20]	[0.32]
Prenatal care = Unknown	-3.18*	-4.29*	-0.27	-3.50*
	[0.51]	[0.57]	[0.28]	[0.41]
N	70,524	70,524	70,426	55,788

Notes:
* p<0.5
Models also include controls for year, female child, married, age (4 dummy variables), education (3 dummies), parity (2 dummies), mother's place of birth (3 dummies), and an intercept.

Appendix

Figure A1. Distribution of births to non-black women by marital status and maternal education, 1990-2001.

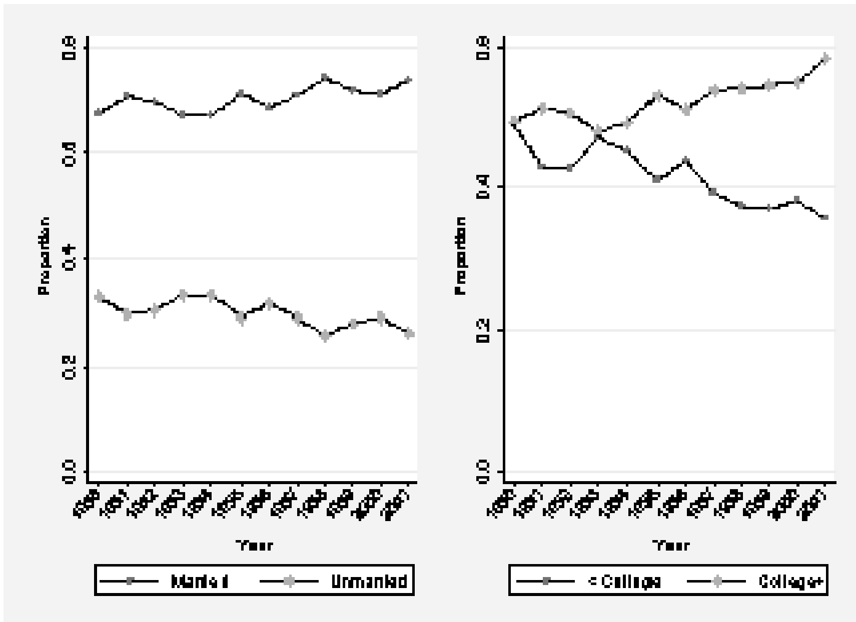

Figure A2. Distribution of births to non-black women by maternal age, 1990-2001.

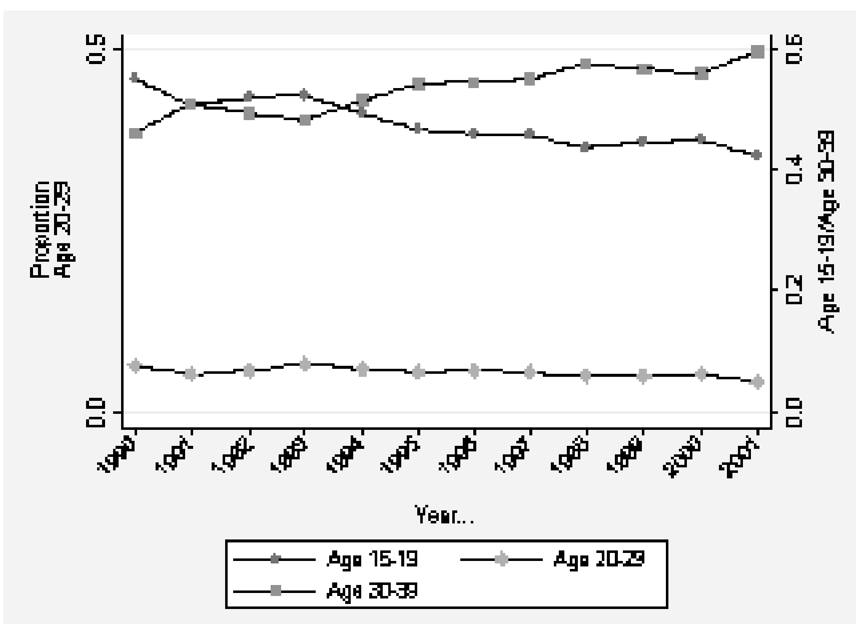

Figure A3. Trends in prenatal tobacco and alcohol use among non-black women, 1990-2001.

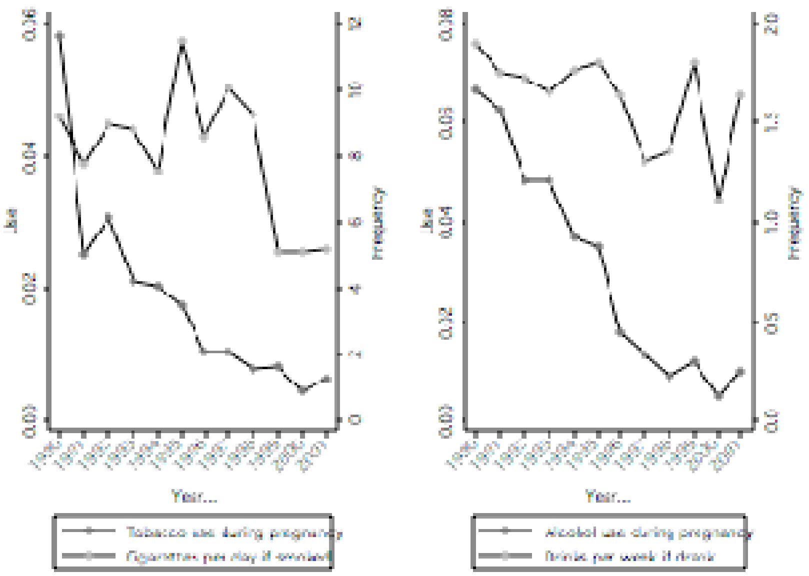

Figure A4. Trends in maternal health among non-black women, 1990-2001.

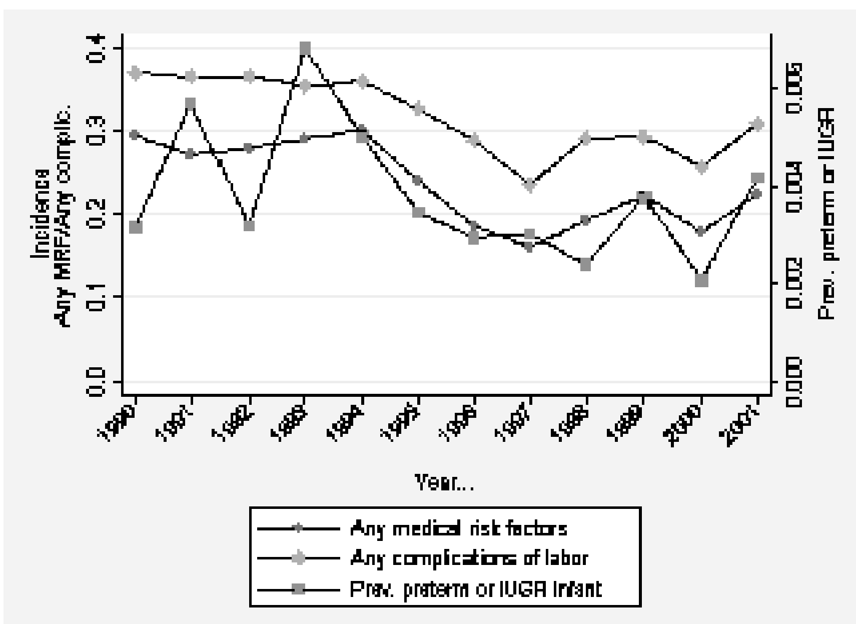

Figure A5. Trends in low birth weight, preterm birth, very low birth weight, and intrauterine growth retardation among non-black infants, 1990-2001.

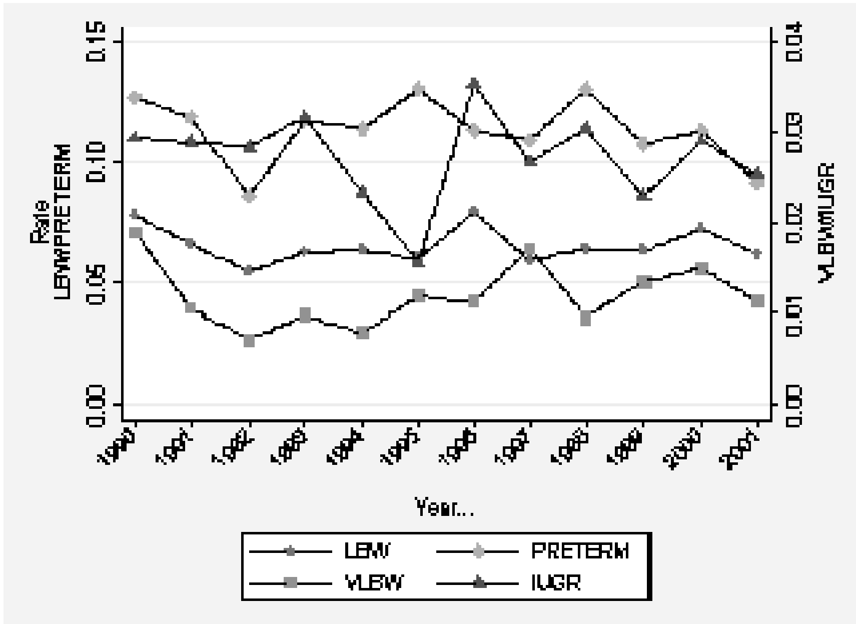

Figure A6. Trends in low birth weight or preterm birth among non-black mothers by marital status and maternal education, 1990-2001.

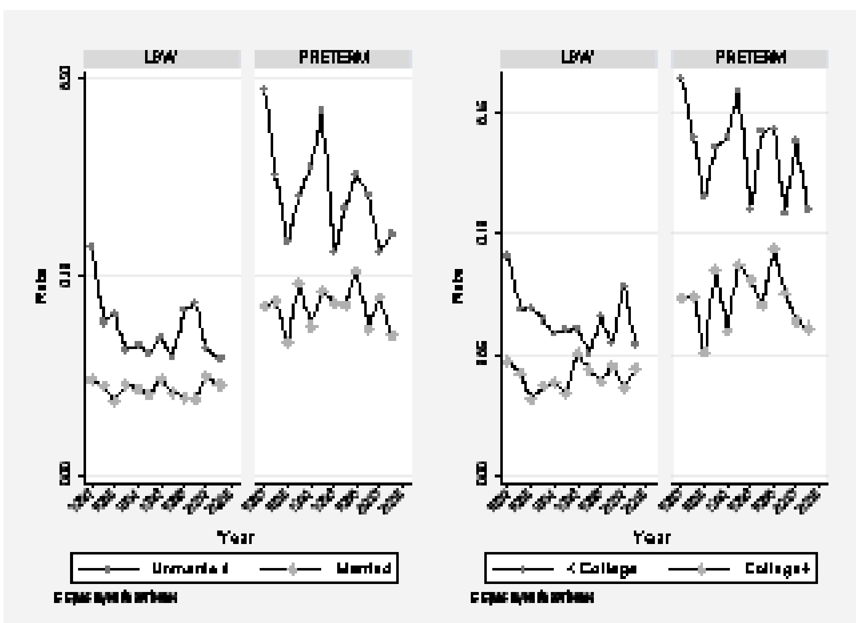

Figure A7. Trends in low birth weight or preterm birth among non-black mothers by maternal age, 1990-2001.

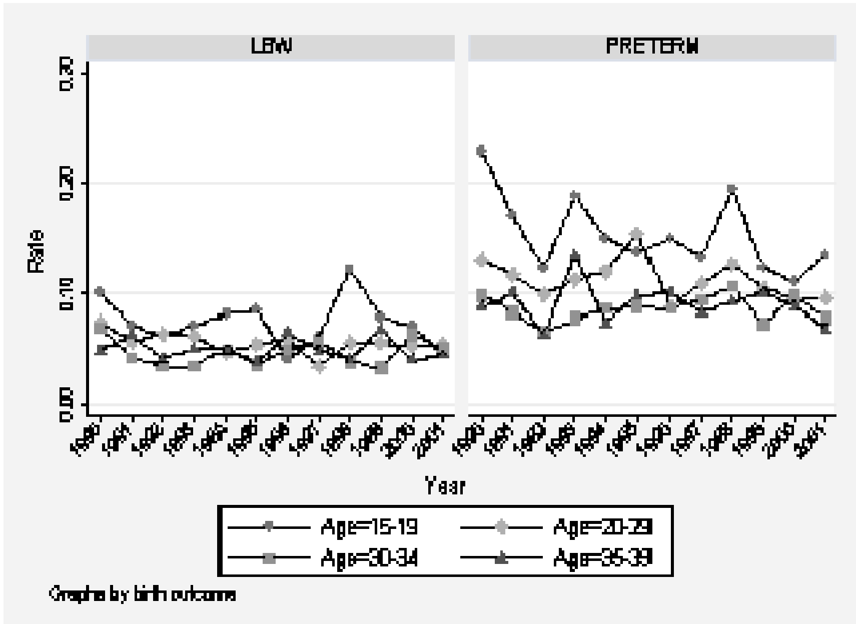

Table A1. Regression-adjusted trends in birth outcomes among non-blacks in DC, 1990-2001

Coefficients of linear time trend x 100 [robust standard errors]

	Panel A				
		Outcome			
		LBW		PRETERM	
Model	**Covariates**	*Coefficient*	*SE*	*Coefficient*	*SE*
1	Female	-0.076	[0.043]	-0.150*	[0.056]
2	Female, Married	-0.062	[0.043]	-0.131*	[0.056]
3	Female, Age (4)	-0.068	[0.043]	-0.136*	[0.056]
4	Female, Married, Age (4)	-0.064	[0.043]	-0.130*	[0.056]
5	Female, Married, Age (4), Education (3)	-0.064	[0.043]	-0.119*	[0.056]
6	Female, Married, Age (4), Education (3), Parity (2), Mother's place of birth (3)	-0.062	[0.043]	-0.111*	[0.056]
7	6 + Preterm (2)	-0.055	[0.039]		
8	6 + Tobacco (2)	-0.038	[0.043]	-0.092	[0.056]
9	6 + Tobacco (2), Alcohol (2)	-0.046	[0.043]	-0.099	[0.056]
10	6 + Tobacco (2), Alcohol (2), Prenatal care (2)	-0.057	[0.044]	-0.094	[0.057]
11	6 + Tobacco (2), Alcohol (2), Prenatal care (2), Preterm (2)	-0.046	[0.039]		
12a	6 + Tobacco (2), Alcohol (2), Prenatal care (2), Preterm (2), Previous preterm or IUGR	-0.046	[0.039]		
12b	6 + Tobacco (2), Alcohol (2), Prenatal care (2), Previous preterm or IUGR			-0.090	[0.057]
13	12 + Medical risk factors (16)	-0.037	[0.040]	-0.061	[0.057]
14	12 + Medical risk factors (16), Complications of labor (16)	-0.031	[0.040]	-0.051	[0.057]

Notes:
* p<0.5
The sample size is approximately 22,000 live singleton births.
The number in parentheses following a variable name is the number of included dummy variables. See Table 1 for categories.
(Table continued on next page)

Table A1 (cont'd). Regression-adjusted trends in birth outcomes among non-blacks in DC, 1990-2001

Coefficients of linear time trend x 100 [robust standard errors]

Panel B					
		Outcome			
		VLBW		IUGR	
Model	**Covariates**	*Coefficient*	*SE*	*Coefficient*	*SE*
1	Female	-0.010	[0.020]	-0.033	[0.030]
2	Female, Married	-0.006	[0.020]	-0.028	[0.030]
3	Female, Age (4)	-0.008	[0.020]	-0.029	[0.030]
4	Female, Married, Age (4)	-0.007	[0.020]	-0.028	[0.030]
5	Female, Married, Age (4), Education (3)	-0.006	[0.020]	-0.025	[0.030]
6	Female, Married, Age (4), Education (3), Parity (2), Mother's place of birth (3)	-0.005	[0.020]	-0.025	[0.030]
7	6 + Preterm (2)	-0.002	[0.018]		
8	6 + Tobacco (2)	0.000	[0.020]	-0.015	[0.030]
9	6 + Tobacco (2), Alcohol (2)	-0.004	[0.020]	-0.014	[0.030]
10	6 + Tobacco (2), Alcohol (2), Prenatal care (2)	-0.008	[0.020]	-0.012	[0.030]
11	6 + Tobacco (2), Alcohol (2), Prenatal care (2), Preterm (2)	-0.002	[0.019]		
12a	6 + Tobacco (2), Alcohol (2), Prenatal care (2), Preterm (2), Previous preterm or IUGR	-0.001	[0.019]		
12b	6 + Tobacco (2), Alcohol (2), Prenatal care (2), Previous preterm or IUGR			-0.012	[0.030]
13	12 + Medical risk factors (16)	-0.003	[0.019]	-0.010	[0.031]
14	12 + Medical risk factors (16), Complications of labor (16)	0.014	[0.018]	-0.011	[0.031]

Notes:
* p<0.5
IUGR: Intrauterine Growth Retarded (LBW among full-term births). Preterm births are excluded from the IUGR analyses.
The sample size is approximately 22,000 singleton births for VLBW and 20,000 for IUGR.

Table A2. Regression estimates of demographic effects on infant health outcomes, births to non-black women in Washington DC 1990-2001 (Model 6)

Coefficients X 100 [robust standard errors]

	Outcome			
	LBW	PRETERM	VLBW	IUGR
Year	-0.062	-0.111*	-0.005	-0.025
	[0.043]	[0.056]	[0.020]	[0.030]
Female	1.348*	-0.728	0.020	1.152*
	[0.299]	[0.401]	[0.134]	[0.212]
Race/ethnicity = Hispanic	0.256	1.566*	-0.320	0.626
	[0.601]	[0.782]	[0.292]	[0.442]
Race/ethnicity = Other	2.226*	4.776*	0.131	2.028*
	[0.756]	[0.975]	[0.356]	[0.595]
Married	-2.343*	-3.147*	-0.710*	-1.344*
	[0.453]	[0.613]	[0.222]	[0.335]
Age = 20-24	0.012	-1.756	0.547	0.303
	[0.793]	[1.097]	[0.334]	[0.609]
Age = 25 -29	0.383	-2.357*	0.674*	0.236
	[0.798]	[1.101]	[0.334]	[0.606]
Age = 30-34	1.033	-1.502	0.946*	0.618
	[0.834]	[1.135]	[0.354]	[0.629]
Age = 34-39	1.739*	-0.633	0.989*	0.692
	[0.883]	[1.195]	[0.363]	[0.653]
Education = High school	0.991	0.338	0.640*	0.339
	[0.582]	[0.778]	[0.294]	[0.446]
Education = College or more	-2.181*	-3.693*	-0.799*	-0.838
	[0.638]	[0.836]	[0.282]	[0.476]
Education = Unknown	0.907	0.112	0.296	-0.540
	[0.788]	[1.054]	[0.376]	[0.540]
Parity = 1 or more	-1.903*	0.398	-0.329*	-1.062*
	[0.323]	[0.433]	[0.141]	[0.228]
Parity = Unknown	18.499	-9.111*	23.688	30.261
	[20.720]	[1.809]	[21.382]	[26.483]
Number of births	22,455	22,370	22,455	20,083

Notes:
* p<0.5
Reference categories are: race/ethnicity white, age 15-19, education less than high school, parity 0, and mother's place of birth Washington DC. Models also include dummies for unknown education and unknown parity and an intercept.
(Table continued on next page)

Table A2 (cont'd). Regression estimates of demographic effects on infant health outcomes, births to non-black women in Washington DC 1990-2001 (Model 6)

Coefficients X 100 [robust standard errors]

	Outcome			
	LBW	PRETERM	VLBW	IUGR
Mother's place of birth = DE/MD/VA/WV	-1.816	-1.839	-1.166*	-0.920
	[1.004]	[1.220]	[0.403]	[0.679]
Mother's place of birth = Other State	-2.375*	-1.609*	-0.909*	-1.170*
	[0.661]	[0.809]	[0.314]	[0.460]
Mother's place of birth = Foreign	-2.930*	-2.045*	-0.805*	-1.284*
	[0.714]	[0.880]	[0.359]	[0.510]
Number of births	22,455	22,370	22,455	20,083

Notes:
* p<0.5
Reference categories are: race/ethnicity white, age 15-19, education less than high school, parity 0, and mother's place of birth Washington DC. Models also include dummies for unknown education and unknown parity and an intercept.

Table A3. Regression estimates of smoking, alcohol, and adequacy of prenatal care on infant health outcomes, births to non-black women in Washington DC 1990-2001 (Model 10)

Coefficients X 100 [robust standard errors]

	Outcome			
	LBW	PRETERM	VLBW	IUGR
Tobacco use during pregnancy	-2.086*	-1.386	-0.809*	-1.091*
	[0.652]	[0.806]	[0.307]	[0.452]
Cigarettes per day	-2.637*	-1.921*	-0.705*	-1.183*
	[0.704]	[0.876]	[0.351]	[0.501]
Alcohol use during pregnancy	7.879*	2.374	2.434	4.286*
	[2.395]	[2.445]	[1.254]	[1.784]
Drinks per week	-0.042	0.384	-0.112	-0.149
	[0.204]	[0.236]	[0.089]	[0.131]
Prenatal care = Adequate	-3.894*	0.306	-0.974*	-2.341
	[1.458]	[1.844]	[0.434]	[1.218]
Prenatal care = Unknown	1.343	-0.936	0.343	1.365
	[0.911]	[0.914]	[0.352]	[0.809]
N	22,455	22,455	22,370	20,083

Notes:
* p<0.5
Models also include controls for year, female child, race/ethnicity (3 dummy variables), married, age (4 dummy variables), education (3 dummies), parity (2 dummies), mother's place of birth (3 dummies), and an intercept.