Accounting for the Change in the Gradient: Health Inequality Among Infants*

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ABSTRACT

This study investigates changes in the relationship between maternal education and infant health using American Vital Statistics data from 1983 to 2000. I find that the disparity, as measured by infant deaths, between infants whose mothers have different levels of education, has remained constant over time while these differences, measured by Apgar scores, have been narrowing over the past two decades. This is in sharp contrast to the increasing disparities in health among adults of different educational backgrounds. Furthermore, one interesting result is that the rate at which the gradient has decreased is faster in the south than in other regions.

A simple decomposition reveals that an increase in access to medical care is the dominant factor explaining the closing gap. Given that Hispanic women tend to have favorable birth outcomes while African-Americans tend to have worse-than-average infant outcomes, the gap has also declined because an increasing share of births to less-educated women (high school dropouts) was accounted for by Hispanics rather than by African-Americans. There are also several behavioral factors which have had an important impact. Namely, the gap has decreased because less-educated women smoke less, but this improvement is partially offset by an increase in the number of less-educated women who gain excessive gestational weight, a symptom that is highly associated with low Apgar scores. Finally, the gap has decreased because an increasing number of college-educated women are having multiple births, a trend that probably reflects the increased use of fertility treatments during the period of study.

JEL: I10, I18, I12

1. Introduction

The gradient in health status – the phenomenon in which people with higher socioeconomic status have better health and longevity than people with low socioeconomic status – is widely recognized. For example, Figure 1 shows that in the United States babies born to women without a high school diploma are twice as likely to die before their first birthday as babies born to college graduates[2]. While many people may be prepared to accept inequality in income as a necessary evil, inequality in health outcomes among infants is arguably less acceptable. One of the World Health Organization's stated targets in its *Health for All 2000* report is to eliminate social inequalities in health. Policy goals in the U.S. also reflect a strong desire to eliminate such disparities. In its *Healthy People 2010* report, the Public Health Service proclaims that one of its two major goals is "to eliminate health disparities among different segments of the population[3]." These health disparities can be analyzed in multiple dimensions, such as race, income and education. In this paper, I focus on infant health disparities based on maternal education. I examine one poorly understood aspect of the inequality in health: the evolution of the infant health gradient over time.

Perhaps one of the most impressive social achievements of the twentieth century is the vast improvement in physical health. For example, life expectancy at birth in the United States in 1901 was 49 years old; by the end of the 20th century, it was 77 years, an increase of over 50%. However, some research has shown that the gradient in health status has worsened among adults (see e.g., Crimmins and Saito 2001; Pappas et al. 1993), reflecting more rapid health gains for

[2] From 1983 to 2000, the infant death rate is, on average, 12 per 1000 births for women without a high school diploma while it is 5 per 1,000 births for women who graduated from college.

3 Healthy People 2010 is designed to achieve two overarching goals: The first goal of Healthy People 2010 is to help individuals of all ages increase life expectancy and improve their quality of life. The second goal of Healthy People 2010 is to eliminate health disparities among different segments of the population (*Healthy people 2010* ,Washington, DC : U.S. Dept. of Health and Human Services, Office of Public Health and Science, [2000]).

people at the high end of the socioeconomic spectrum. Since for adults the health gradient has widened over time, a natural question to pose is whether the same is true for infants. To my knowledge, no previous study has examined changes in the infant health gradient in infant health by education or by income – this study is a first step in this line of research.

This paper uses individual-level data from U.S. birth and death certificates from 1983 to 2000 to examine the evolution of inequality in infant health outcomes. I explore the change in the infant health gradient using logistic regressions. My primary measures of infant health outcomes are low Apgar[4] scores and infant death rates. The former is arguably the best indicator of health at birth (see Almond, Chay, and Lee [Forthcoming]). The latter depends not only on how healthy the baby is at birth, but also on what kind of medical care he or she receive before (pre-natal) and after birth and on parental behavior during the first year. If babies born to low educated mothers are more likely to die from post-neonatal diseases such as diarrhea or pneumonia, or if they are more likely to be subject to less-than-favorable home environments, then it is possible to only see convergence in low Apgar scores but not in infant death rates.

In sharp contrast to the increasing health gradient among adults, the main findings of this paper suggest that (1) the gradient in infant death stays constant over time and (2) the gradient in low Apgar scores has indeed narrowed.

After finding this surprising result with respect to Apgar scores, the natural question to ask is what accounts for this closing trend. I implement a decomposition technique that focuses on three main factors: first, changes in behavior (e.g., reductions in smoking, increases in fertility

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[4] The Apgar score is designed to quickly evaluate a newborn's overall physical condition after delivery. A perfect Apgar score of 10 means an infant is in the best possible condition. In this paper, an infant with an Apgar score less than or equal to 8 is defined as having a low Apgar score; as a result, 10% of infants fall into the low Apgar score group.

treatment); second, demographic changes (e.g., a rising fraction of all U.S. births are accounted for by Hispanics rather than by African-Americans); and third, access to medical care, which is likely to be linked to the rapid increases in public health insurance coverage which took place during the late 1980s and early 1990s.

I find that access to medical care and changes in maternal behavior are the most important factors in the decreasing health gradient. Specifically, access to medical care accounts for 40% of the decrease in the gradient of low Apgar scores. Maternal behavior changes such as delays in pregnancy, fertility treatments (inferred from an increase in multiple births), unhealthy gestational weight gains, and reductions in smoking, together explain 30% of the closing gap. Demographic changes explain 12% of the gap.

Although babies born to better educated mothers are healthier than those born to less educated mothers, it is comforting to know that over the past two decades, the infant health gradient has been narrowing (even if it has not yet disappeared). For example, in 1983, if babies born to low educated mothers had been born to high educated mothers, approximately 21,365 fewer newborns would have had low Apgar scores. By 2000, this "excess" had declined to approximately 4,121[5]. This paper also suggests that the rapid Medicaid expansion in the late 80s and early 90s is the most important factor in accounting for the closing gap. However, this work also highlights the importance of maternal behaviors and demographic changes in driving trends in infant health.

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[5] In 1983, there were 577,440 babies born to low educated mothers. In 1983, the percentage of low Apgar score babies among low educated women was 14.4 while the percentage of low Apgar score babies among the high educated group was 10.7. Therefore, the number of "excess" low Apgar score babies was 21,365 (577,440*(0.144 - 0.107) =21, 365). In 2000, these percentages were 10.1 and 9.4 among the low educated and high educated groups, respectively. Taken together with the fact that 588,770 babies were born to low educated mothers in the year 2000, we find that the number of "excess" low Apgar score babies in 2000 was 4,121 (588,770*(0.101-0.094)=4,121).

The rest of the paper proceeds as follows: Section 2 reviews the relevant literature. Section 3 discusses the mechanisms underlie infant health formation. Section 4 and 5 provide an overview of the data and methods. Results appear in Section 6. Section 7 presents some specification checks, and Section 8 offers some concluding remarks.

2. Previous Literature

In this paper, educational attainment, rather than income, is used as an indicator of socioeconomic status. A mother's education level can affect child quality not only by changing the household budget constraint but also by changing the mother's behaviors. Namely, education may affect the budget constraint both directly through higher earnings for the woman (Card [1999])[6] and indirectly through an improvement in her marriage market prospects (Behrman and Rosenzweig [2002]). In addition, even holding constant the budget constraint, a mother's education may improve child quality if it induces her to behave in a healthier way (e.g., reduction in smoking); to make better decisions (e.g., eat healthier, gain adequate gestational weight); or to alter her preferences (e.g., education may increase one's patience (Becker and Mulligan[1997]) or risk aversion).

Using education in this context has two main advantages. First, education is a more permanent and stable measure of socioeconomic status than income. For example, income may be affected by the health of the unborn child through reductions in maternal labor supply or high medical bills. Second, data on educational attainment is collected for all mothers, not only those who are employed.

[6] The private returns to schooling in the United States in the 1990s are believed to be about 8-12%: each extra year of schooling appears to be associated with an 8-12% increase in earrings. See Card (1999) for a comprehensive survey of the evidence on the private returns to schooling.

Extensive research concerning the social determinants of health has revealed that education is strongly associated with a broad range of health measures (see Marmot [2004] for a review), but little is known about the evolution of educational-related disparities over time. Moreover, all the previous studies on health disparities over time are centered on *adults*[7]. Thus, in this section, I draw from the literature on the changes in educational-based health inequality among adults.

Research on adults has shown that the gradient in health status has steepened, in the sense that the same difference in years of education is now associated with a larger difference in the probability of death. For example, Koskinen (1985) showed that socioeconomic differentials in life expectancy have reportedly widened in England and Wales. Using a series of Decennial Supplement on Occupational Mortality data, he showed that age-adjusted mortality rates have declined in all social classes, but differences between classes are persistent. Later, using the same data, Pamuk (1985) confirmed that social-class inequality in mortality among occupied and retired males declined in the 1920s, then increased during the 1950s and 1960s so that by the early 1970s it was greater than it had been in the early part of the century. For married women, using husband's social class as a socioeconomic indicator, a similar increase in inequality with respect to mortality rates occurred from the 1950s to the 1970s.

More recent studies in the United States further support these findings. For example, Feldman et al. (1989) suggested that in 1960, there was little difference in mortality by educational level among middle-aged and older men. Since 1960, however, death rates among men declined more rapidly for the more educated than the less educated, resulting in a substantial educational differential in mortality in 1971-1984. Pappas et al. (1993) suggested that in the

7 A few researchers have investigated trends in infant mortality by race (Collins and Thomasson 2002; Culter and Meara 2003) but not by income or by education.

1980s, the differences in mortality across educational groups were larger than those in 1960. Their analysis, however, was limited to a comparison of two selected dates, 1960 and 1986. Preston and Elo (1995) later confirmed that educational inequality in mortality was greater between 1979 and 1985 than in 1960 for white men. For white women, however, mortality differentials based on education have narrowed rather than expanded since 1960; these findings contradict those of Pappas et al. (1993). Crimmins and Saito (2001) found large and growing educational differences in healthy life expectancy in the United States from 1970 to 1990. Schoeni et al. (2001, 2005) found that educational differences in old-age disability rates have been declining since the early 1980s but the gains have been concentrated among the most educated. Thus, this line of research concludes that over the twentieth century general health status among Americans has strikingly improved. But at the same time, important and persistent health differences based on socioeconomic status have grown. This paper expands this line of research to include the evolution in the gradient in infant health, an issue that is of relevance to public policy makers and researchers alike.

3. A Framework for Exploring Infant Health

The regressions used in this paper are guided by a simple model in which the likelihood of an adverse infant outcome is influenced by three mechanisms: (1) maternal behavior, such as smoking, unhealthy weight gain, delaying fertility or seeking fertility treatment, (2) demographic changes (for example, the rising fraction of U.S. births accounted for by Hispanics rather than by Blacks), and (3) access to medical care. Variables associated with these mechanisms can be viewed as inputs into a health production function; the function captures the means through which variables related to infant health translate into various infant health outcomes. Understanding these mechanisms provides guidance as to which controls are necessary in reduced form estimates and facilitates the interpretation of the decomposition implemented later in this paper.

3.1 Maternal Behavior Changes

Maternal behavior during pregnancy is important for producing healthy babies (Grossman, [1972]; Kenkel [1991]). The measures of maternal behavior which I use are maternal age, marital status, whether the mother smokes, and gestational weight gain. Another interesting component is the use of fertility treatment which is unobserved, but which I infer through the prevalence of multiple births (see discussion below).

Many studies show a U-shaped relationship between maternal age and pregnancy outcomes[8]. Out-of-wedlock birth has long been recognized as one of the demographic risk factors associated with infant mortality and other adverse infant health outcomes (Bennett [1992]). Data used in this study show that the infant death rate for unmarried mothers was 1.9 times higher than that of married mothers during the sample period[9]. Maternal smoking adversely affects the health of both mother and child[10]. Both inadequate and excessive weight gains are important risk factors. Inadequate gestational weight gain has been reported to increase the risk of preterm delivery and the risk of having an infant who is small for gestational age

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8 For example, young adolescents (12-17 years) have long been associated with higher infant mortality rates (Cook [2005]). With more women postponing childbearing until their later reproductive years, there is increased awareness and concern about advancing maternal age and infant health. Some studies have shown babies born to older mothers have an increased risk of low birth weight (e.g., Cnattingius, Berendes, & Forman, [1993]; Cnattingius et al., [1992]), of preterm8 delivery (e.g., Astolfi & Zonta, [2002]; Cnattingius et al., [1992]) and of being small for gestational age (SGA)8 (e.g., Dildy et al., [1996]; Dollberg et al., [1996]).

9 Infant death rate was 6.9 per 1000 births for married mothers, while it was 12.9 for unmarried mothers during the sample period (U.S. Vital Statistics, 1983 to 2000).

10 For example, Lien and Evans (2005) find that states that adopted large cigarette tax hikes had a corresponding decrease in the percentage of pregnant women who smoke. Meara (2001) documents a strong correlation between smoking during pregnancy and the probability of having a low birth weight infant. Almond, Chay and Lee (Forthcoming) find significant negative effects of smoking on birth weight and Apgar score. Chomitz, Cheung and Lieberman (1995) shows that if all women stopped smoking when they became pregnant, at least 20 percent of all low birth weight infants could be avoided.

(SGA) (Abrams [1989]). On the other hand, excessive weight gain is associated with complications in pregnancy such as higher rates of hypertension, C-section, induction of labor and large-for-gestational-age infants (Jensen [2005]; Thorsdottir [2002]; Wanjiku Kabiru [2004]). One limitation, however, of previous studies of the effects of excessive weight gain is that they use small hospital data sets without information on Apgar scores rather than using the Vital Statistic data which includes information on Apgar scores and has large sample size. Thus this work is able to present a new finding: a positive relationship between excessive weight gain and low Apgar scores.

The last factor related to maternal behavior that I investigate is the effect of fertility treatments. Multiple births reduce the health gap, but do so in an undesirable way by decreasing infant health among highly educated women. Although I do not have data on fertility treatments, the sharp increase in the number of multiple births in certain groups can be used to infer the prevalence of this procedure[11]. Compared with singleton births, children of multiple births usually have more complications, such as increased risk of miscarriage, pre-eclampsia, growth retardation, and preterm delivery. For example, Schieve (2002) shows a positive relationship between (very) low birth weight and multiple births.

3.2 Demographic Changes

Since a rising fraction of U.S. born babies are accounted for by Hispanics rather than African-Americans, it is important to address differences in health outcomes among various racial groups. Hispanics and African-Americans have very different average infant outcomes as

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[11] Fauser (2005) shows that although an association between older females and multiple gestations is clear, the delay in childbearing accounts for no more than 30% of the recorded overall increase in multiple pregnancies. Furthermore, the rate of triplet and higher-order multiple pregnancies has increased four-fold over the same time period, a trend that can be attributed almost entirely to fertility treatment.

compared to whites. For example, Forbes (1991) shows that despite a higher level of risk factors such as low socioeconomic status, delayed use of prenatal care, and higher parities[12], Hispanic women tend to have favorable birth outcomes, a phenomenon that has come to be termed an "epidemiologic paradox". However, research also shows that these positive effects are restricted to those who are foreign-born but not to American-born Hispanic women. For example, Collins and Shay (1994) shows that in very low-income (less than $10,000/year) census tracts, Mexican and other Hispanic infants with US-born mothers had low birth weight rates of 14 and 15%, respectively. In contrast, Mexican and other Hispanic infants with foreign-born mothers who resided in these areas had low birth weight rates of 3 and 7%, respectively.

Infant mortality among blacks in the U.S. has historically been about twice that of whites (National vital statistics reports, NCHS 2002). Numerous studies have argued that the lower average relative birth weight of African-American babies is the primary reason for the persistence of black-white infant mortality differentials (e.g., Lu and Halfon [2003])[13].

3.3 Access to Medical Care

It is widely believed that expanding medical care can improve infant health. For example, Currie and Gruber (1996) show that increased eligibility for public health insurance increased the utilization of medical care and lowered the incidence of infant mortality[14]. Inadequate use of prenatal care by the poor is generally viewed as an important determinant of their relatively

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[12] Parity is defined as the number of times that a mother has given birth to a fetus with a gestational age of 24 weeks or more, regardless of whether the child was born alive or was stillborn.

[13] However, there is no consensus in the literature as to whether genetic factors are responsible for the lower average birth weight of African-American babies. Race may possibly reflect genetic differences but it may also be a proxy for health habits, familial support, exposure to stress, or maternal health endowments – factors that are not easily observable by researchers. Therefore, when drawing causal inferences, it is necessary to be aware of key factors that may be correlated with race and which may significantly influence infant outcomes.

[14] Currie and Gruber (1996) find that a 30-percent-point increase in eligibility would lead to a reduction of 8.5 percent in infant mortality rate.

worse infant health outcomes; furthermore, it provides a more general indicator of access to medical care for pregnant women. Rapid expansions in Medicaid, the public health insurance program for poor women and children, in the late 1980s and early 1990s may have caused a narrowing in the infant health inequality gap by improving access to medical care especially among low educated women.

4. Data

The main source of data used in this study comes from the Linked Birth and Infant Death files (LBID) released by the National Center for Health Statistics (NCHS). The data are publicly available for periods1983-1991 and 1995-2000. These data contain linked information from birth and death certificates. Unfortunately, this linkage is not provided by NCHS for the years 1992, 1993 and 1994. For these three years, the Vital Statistics Detailed Natality data are used instead. Although infant morality information is not available in the Natality data, it contains several other infant health measures like Apgar scores which are of interest to this work.

The combined LBID and Natality data sets provide a census of virtually all of the approximately 4 million births that occur in the United States each year. Beginning in 1989, the Vital Statistic files include self-reported data on maternal smoking during pregnancy and gestational weight gain. My decomposition analyses therefore focus on the period between1989 and 2000 when these two measures of maternal behavior are available. States that do not report maternal education, Apgar scores, and relevant explanatory variables for all of the sample years are excluded for consistency. States that do not report smoking behavior and gestational weight gain after 1989 are also excluded[15]. To ease computation time, I then take a sample of 10%.

[15] California, Texas, Washington and New York do not report mother's education. California, Indiana and South Dakota do not report maternal smoking. California and Texas do not report Apgar scores. Louisiana, Nebraska and

These exclusions provide a sample that consists of around 4,412,000 observations from 43 states. This large sample size allows the analysis of relatively rare infant outcomes with high precision and enables us to conduct detailed analysis by maternal education groups.

My primary measures of health outcomes are low Apgar scores and infant death rates. The Apgar score is an overall measure of an infant's health at birth. It was designed to quickly evaluate a newborn's physical condition after delivery and to determine any immediate need for extra medical or emergency care. Apgar scores are a composite index and take into account activity (and muscle tone), pulse (heart rate), grimace (reflect irritability), appearance (skin color), and respiration (breathing rate and effort); each factor is scored on a scale of 0 to 2. The sum of these five factors is the Apgar score. Thus scores range from 0 to 10, with 10 being the highest possible score. Appendix Table 1 shows the distribution of Apgar scores. In this study, a low Apgar score is defined as 8 or below, which results in approximately 10% of infants being in this category. It is important to recognize that Apgar scores and infant death rates measure health at different times. Low Apgar scores reflect the underlying health of an infant at birth; however, infant mortality rates measure infant health up to age one, thus including the effect of any parental or medical interventions.

This study distinguishes between three education groups: high school dropouts (less than 12 years of schooling completed), high school graduates (12 to 15 years of schooling completed), and college graduates (16 or more years of schooling completed). I use these categories in part because they coincide with the assignment of major educational credentials, high school and college degrees, and in part because they mark the points on the education distribution at which differences in infant health by education level are very large. The striking differences across

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Oklahoma do not report gestational weight gain.

education groups can be seen in Table 1 which provides key summary statistics. High school drop-out mothers are 2.26 times more likely than college graduate mothers to have children who die before age one and 2.53% more likely to have children with low Apgar scores.

Besides differences in the two infant health measures above, there are also substantial differences in maternal characteristics by education group. Table 1 provides summary statistics related to measures of maternal behavior. Highly educated mothers are three times more likely to give birth after age 40 as compared to high school dropout mothers. College graduate mothers are also more likely to have multiple births, more likely to be married, and less likely to smoke during pregnancy; they are also less likely to gain more than 60 pounds or gain less than 15 pounds during pregnancy. As for demographic backgrounds, college graduate mothers are more likely to be white and less likely to be Hispanic or African-American. Finally, college educated mothers are twice as likely to report having received adequate prenatal care[16], both in terms of the timing of initiation of prenatal care and the number of visits.

Figures 2, 3 and 4 further explore maternal behavior characteristics, demographic factors, and access to medical care, respectively, by expanding the analysis over time. Understanding these trends is important because differential trends in these variables across education groups may potentially contribute to educational disparities in infant health.

In Figure 2, I find that there is an increasing trend towards multiple births among college-educated mothers while the probability of multiple births remains constant among high school dropouts. The probability of having multiple births for high educated women has doubled over the passed two decades; it increased from 2% in 1983 to 4% in 2000. We also see that (1) among the high education group the percentage of mothers over 40 years old has gone up

[16] The criterion for adequacy of prenatal care is based on Kessner criteria. The month in which prenatal care was initiated, the number of prenatal visits, and gestation are used to evaluate whether prenatal care is adequate.

steadily over time; (2) an increasing number of low-educated women gain over 60 pounds during their pregnancies; and (3) there is a more rapid decline in smoking among less educated women than among high educated women (where rates were already low).

Figure 3 shows there were large demographic changes from 1989 to 2000 for all education groups. With the influx of Hispanic immigrants over the past two decades, the increasing fraction Hispanic should come as no surprise. The share of high school dropout women who are Hispanic increased from 12% to 28%, while the share of high school dropout women who are African-American decreased from 28% to 23%. Shares of black and Hispanic college-educated women have shown relatively little change over time. Given differences in average birth outcomes between groups, one would expect this shift in demographic composition to improve health among children of less-educated women, and to close the gap in outcomes between less-educated and more-educated women.

Regarding access to medical care, Figure 4 shows that the percentage of low educated women having adequate prenatal care over time. In line with the expansion of Medicaid eligibility, we see an increasing fraction of babies born to low educated mothers who have adequate prenatal care. The percentage increased from 45% in 1989 to 55% in 2000. In contrast, there was only a 1 % increase in adequate prenatal care for high educated mothers, from 85% in 1989 to 86% in 2000. Given the positive effect of the Medicaid expansion on low educated mothers, improvements in medical care can be expected to close the infant inequality gap and, hence, are expected to positively contribute to the closing gradient.

5. Methods

In order to investigate the development of the gradient over time, I begin by graphing the relationship between infant health measures and maternal education over time. Figures 5a and 5b plot the conditional expectation of low Apgar scores and infant death rates as a function of time based on maternal education. The health gradient is immediately apparent – over time, infants born to high educated mothers always have a lower probability of low Apgar scores and a lower infant death rate.

A key new finding of this study is that the gap in infant mortality has stayed relatively constant over time while the gap in low Apgar score has been decreasing over the past two decades. As shown in Figure 5a, the incidence of low Apgar scores is higher for infants born to less-educated mothers (line with triangles) than for infants born to highly educated mothers (line with circles). While there is a good deal of variation in the incidence of low Apgar scores, it is obvious that the gap between the low and high education groups narrows over time. In 1983, infants from the less educated groups were 3.8 percent more likely to have a low Apgar score than infants from the high education group. By 2000, however, this percentage had decreased to 0.5 percent. Since there is little evidence of an increase in low Apgar scores among infants of high educated mothers, it appears that the narrowing gap is primarily due to a decrease in the incidence of low Apgar scores among infants born to less educated mothers.

Figure 5b plots the number of deaths per 1000 births based on maternal education groups. This figure shows that infants born to less educated mothers always have higher death rates, and that the differences in death rates have stayed relatively constant over time.

In order to further investigate the gradient, I estimate a model of the following form:

$$(1)\quad P_{it} = \beta_0 + \beta_1 L_{it} + \beta_2 M_{it} + \beta_3[L * yeartrend]_{it} + \beta_4[M * yeartrend]_{it} + \beta_5[year]_t + \beta_6 X_i + \varepsilon_{it}$$

where P_{it} is the probability of a negative infant health outcome for the i[th] respondent in sample year t. Specifically, P_{it} is the probability of a low Apgar score, which measures infant health at birth, and the probability of infant death within the first 12 months. L and M are dummy variables for mothers who in the low education group (less than 12 years of schooling completed) and in the middle education group (12 to 15 years of schooling completed), respectively; the *yeartrend* is a linear index of the sample year where 0 represents 1983 and 19 represents 2000; *year* includes a full set of year dummies. The vector X_i includes time-invariant covariates measured at the individual level.

In this model, the main coefficients of interest are β_3 and β_4, which represent the changes in the gradient over time for the low and the middle education groups, respectively. For example, a positive β_3 indicates an increasing difference in infant health between the low and high education groups, while a negative coefficient indicates that this gap actually narrows.

In order to test whether the results of model (1) are robust to the specification of a linear time trend, in the Appendix, I re-estimate the model using a full set of year dummies rather than a linear year trend. I plot the coefficients of the interaction terms between low and middle education dummies and the year dummies to ensure that the results are consistent.

In order to examine the factors that account for the evolution of the gradient, I implement a decomposition method similar to that proposed by Smith and Welch (1989) and Heckman, Lyons, and Todd (2000). Specifically, I examine the influence of three broad sets of factors: 1) maternal behavioral changes, as measured by whether a mother gives birth at an unhealthy maternal age, experiences excessive weight gain, has multiple births, or smokes during pregnancy; 2) demographic composition changes, including an indicator for whether a mother is Hispanic and an indicator for whether a mother is black; and 3) access to medical care, consisting of a dummy for adequate prenatal care and a dummy for inadequate prenatal care.

To understand this decomposition, let x refer to the three sets of variables mentioned above with the associated vector of coefficients $\widehat{\beta}$. Let t be the current year and τ be the base year, while H denotes high education group and L denotes low education group.

Let $\overline{x}_t^H$, $\overline{x}_t^L$, $\overline{x}_\tau^H$, $\overline{x}_\tau^L$ denote the mean vectors of high and low education group characteristics at different points in time. Then, the change in the low education group infant outcome minus the high education group infant outcome between time periods t and τ is decomposed in the following way:

$$
\begin{aligned}
&\left[\left(\overline{x}_t^L \hat{\beta}_t^L - \overline{x}_t^H \hat{\beta}_t^H\right) - \left(\overline{x}_\tau^L \hat{\beta}_\tau^L - \overline{x}_\tau^H \hat{\beta}_\tau^H\right)\right] = \\
&\left[\left(\overline{x}_t^L - \overline{x}_t^H\right) - \left(\overline{x}_\tau^L - \overline{x}_\tau^H\right)\right] \hat{\beta}_\tau^H \text{.............}(a) \\
(2) \qquad &+\left(\overline{x}_t^L - \overline{x}_\tau^L\right)\left(\hat{\beta}_\tau^L - \hat{\beta}_\tau^H\right) \text{.......................}(b) \\
&+\left(\overline{x}_t^L - \overline{x}_t^H\right)\left(\hat{\beta}_t^H - \hat{\beta}_\tau^H\right) \text{......................}(c) \\
&+\overline{x}_t^L \left[\left(\hat{\beta}_t^L - \hat{\beta}_t^H\right) - \left(\hat{\beta}_\tau^L - \hat{\beta}_\tau^H\right)\right] \text{..........}(d)
\end{aligned}
$$

The first two terms of (2) measure the contribution of changes in characteristics, valued at base-year coefficients. Term (a) measures the change in the infant health inequality predicted by changes in the characteristics of the two groups over time. These changes are valued using base-year high education group parameters. For example, if differences between the characteristics of high educated and low educated mothers had diminished over time, then this component of the infant health gradient would have decreased. Term (b) measures the additional change in the infant health gradient predicted by the change in low education group characteristics, taking into account that the base-year coefficients of the high and low education groups differ. For example, if returns to medical care (in the base year) are higher among the high education group, then an increase in the overall mean values of medical care leads to an increase in the infant health disparity because the high educated benefit disproportionately.

The last two terms measure the contribution of changes in coefficients. Term (c) measures the effect of a change in the infant health gap due to a change in the returns to a specific characteristic; taking into account the fact that low and high education group mean characteristics differ in the current year. In other words, if the low educated are less likely to have a characteristic for which the return decreases, then the gradient decreases. For example, if the return to medical care decreases over time, we can expect the infant health disparity to decrease because high education groups have more adequate medical care than low education groups. Term (d) measures the predicted change in the infant health disparity that occurs because high and low education groups become more similar in terms of coefficients, valued at current-year low education group characteristics. This term implies that if the coefficients of the less educated improve more than the coefficients of the high educated, the gap decreases due to a convergence in coefficients.

6. Results

6.1 The Trend in Health Inequality

Table 2 displays the effects of maternal education on infant health outcomes as well as the evolution of the gradient over time. Since the coefficients of logistic regressions are not directly interpretable, the marginal effects of the regressions are reported. The first column shows the estimated coefficients where the dependent variable is an indicator of whether the infant had a low Apgar score from 1983 to 2000. Two findings stand out. Looking at the main effects, the first thing to notice is the differential infant health outcomes based on maternal education groups. The marginal effect of low education is 4 percentage points and the marginal effect of middle education is 2 percentage points. That is, the probability of being a low Apgar score baby is 4 (2) percentage points higher for a baby born to a low educated (middle educated) mother versus a highly educated mother.

The other key finding is that the trend in the health inequality gap, measured by a low Apgar score, has indeed been *decreasing* over time. The interaction terms between the time trend and education levels are negative and significant, indicating that the differences in low Apgar scores have decreased since the early 1980s. As a gauge of the size of the change in the gap, we see that the education-based infant health gap between college-graduate and high school dropout mothers has decreased by 4 % (-0.00166/0.04012) per year.

The effects on infant death are shown in column 2 of Table 2. The estimated effects on the interaction terms suggest that the gradient has stayed relative constant over time. The interaction terms between the time trend and education levels are small in magnitude and not precisely estimated. Therefore I conclude that the gap with respect to infant death has stayed constant over time. In the appendix, I show that the results (i.e., the gradient decreasing with respect to low Apgar score and the gradient remaining constant with respect to infant death rates) from Table 2 are robust to using year dummies rather than time trends.

Table 3 shows the estimated effects of the other covariates included in model (1). Columns 1 and 2 are for the whole sample period (1983~2000) while columns 3 and 4 cover 1989 to 2000, the period when information on gestational weight gain and smoking behavior is available. As mentioned in section 3, the effects of maternal age and weight gain on infant health outcomes are highly non-linear. I therefore include a dummy for teenage mothers and a dummy for mothers older than 40 to capture the non-linear effect of maternal age on infant outcomes. The effects of weight gain on infant health are also non-linear. To capture the non-linear effects, I include a dummy for weight gain less than 15 pounds and a dummy for weight gain over 60 pounds.

From Table 3, consistent with our expectations, we see that Hispanics, foreign-born mothers, and married mothers are less likely to have babies born with low Apgar scores. Furthermore children born in multiple births, born to high school dropouts, whose mother smokes, or whose mother is of high parity are more likely to have a low Apgar scores. The negative effect of multiple births on low Apgar score is particularly large; a multiple birth baby is 11 percent more likely to have low Apgar score than a singleton birth baby (i.e., only one child born to a mother). Among the various factors, this effect is the most salient.

Particularly interesting from column 2 in Table 3 are the marginal effects of the dummies for weight gain during pregnancy. I find a positive effect of inadequate weight gain on a low Apgar score, a finding that is not previously documented in the literature. Mothers with weight gain less than 15 pounds are 3.14 percentage points more likely to have low Apgar score babies. A new finding of this paper is that babies whose mothers have weight gain over 60 pounds also have a higher probability of a low Apgar score; the effect is 0.43 percentage points. As for the effects of weight gain on infant death, I find that inadequate weight gain results in higher infant death rates; however, excessive weight gain does not seem to have similar negative effects on infant death.

In order to assess how much of the gap is accounted for by different groups of covariates, Figure 6 plots the conditional expectation of low Apgar score for high and low education groups controlling for different sets of covariates based on the hypotheses described in section 3. More specifically, the solid line is the unconditional expectation, which for comparison is the same as in Figure 5a. The dashed line is the conditional expectation when demographic variables are controlled. The dotted line is the conditional expectation when I add in controls for demographic variables as well as access to medical care. The dotted-dashed line is the conditional expectation controlling for all three sets of variables.

From Figure 4, it is clear that as each set of controls is added to the regression the gap between the high and low education groups closes; we see that different control variables can account for a large portion of the gap. However, from this graph alone, it is difficult to assess how much of the gradient each set of variables accounts for because the order in which the controls are added matters. Furthermore, this gap does not take into account the effects of changes in coefficients.

For a more rigorous analysis, I follow the aforementioned decomposition method. This decomposition method assesses the contribution of each control variable and differentiates between the changes in gradient that are due to changes in characteristics verses changes in coefficients (i.e., the returns to certain characteristics). For example, if the coefficient from a linear regression model associated with adequate prenatal care is -0.03 and the dependent variable is whether a baby has a low Apgar score, then having adequate prenatal care is associated with a 3% lower probability of having a low Apgar score baby. In other words, having adequate prenatal care has a negative 3% return with respect to low Apgar scores. Therefore, if a coefficient changes over time, we then interpret this as a change in the return to a certain characteristic over time. For example, increases in the return to medical care over time means that having adequate prenatal care is associated with a smaller gain in Apgar scores in past years than in the present. In other words, the health differences between babies who receive adequate prenatal care and those who do not receive prenatal care increases over time.

6.2 Decomposition Results

Table 4 shows the results of the decomposition[17]. Overall, access to medical care is the dominant factor in explaining the closing infant health gradient as measured by a low Apgar score. All else equal, the increased likelihood of access to proper medical care for low educated women narrows this difference by 39.5%. However, although access to medical care is certainly

17 In the decomposition, I use1989 as the base year and 2000 as the current year. 1989 is the first year that data on weight gain and smoking behavior is available and 2000 is the latest year of this study.

a driving factor, it explains less than half of the closing gradient. Maternal behavior changes and demographic changes also contribute significantly, explaining 29% and 12%, respectively; 18% is not explained by the variables I include in my decomposition. Overall, 33.5% of the variation is explained by changes in characteristics and the remainder is accounted for by changes in coefficients, or, as described above, changes in the returns to characteristics.

As seen in Table 4, the four most important factors in explaining the closing infant health gradient are adequate prenatal care, foreign mothers, married mothers and multiple births. In what follows, I briefly discuss each of these factors.

The single largest component is adequate prenatal care; it reduces the gap by 37%. This finding suggests that the increases in access to medical care, perhaps cause by the rapid Medicaid expansion in the late 80s and early 90s, played a significant role in closing the infant health gap.

Being a foreign-born mother is perhaps the most important demographic variable, accounting for 12% of the closing gap. Coupled with the fact that 80% of foreign-born low educated mothers are Hispanic, this result is consistent with the current literature that claims that foreign-born Hispanic immigrants have better infant health outcomes. When assessing the effects of the influx of Hispanics on the infant health gradient, it is important to look not only at the effects of Hispanic but also the effects of being foreign-born. Combining the positive effect of being foreign-born (12.1%) and the negative effect of being Hispanic (-5.9%), the net effect of the influx of Hispanic women over the past few decades accounts for approximately 6.2% (12%-5.9%)[18] of the closing of the infant health gap in low Apgar scores. This finding suggests that if

[18] 80% of the foreign born mothers are Hispanic.

the flow of Hispanic immigrants continues, we may see further decreases in the infant health gap.

Of the maternal behavior variables, whether a mother is married explains 12% of the closing gradient. This may seem counterintuitive since the percentage of married mothers among the low educated has decreased over time and in general married mothers give birth to healthier babies. However, most of the positive contribution of being married comes from changes in the returns to being married (i.e., in coefficients) rather than changes in characteristics and since the positive effect of being married has been decreasing over time, these results are less surprising. In short, since there is a higher percentage of unmarried mothers in the low education group versus the high education group, and since the negative effect of being an unmarried mother has been decreasing over time [See Figure 2 in the Appendix], low educated mothers benefit disproportionately, thus narrowing the gradient.

The last important component is multiple births - accounting for 11%. This should not be surprising due to the large increase in multiple births among highly educated women. Although decreases in the infant health gap are generally a good thing, the increase in multiple births closes the gap in a less desirable way. Instead of improving infant health at the low end, it worsens infant health at the high end of distribution.

7. Specification Checks

7.1 Selection Issue

When interpreting changes in the gradient using fixed education groups, it is important to address issues of selection. Over time, on average, an increasingly higher level of educational attainment has been achieved. The crux of the selection problem is that people with the same characteristics are more likely to go to college in 2000 than in 1980. Figure 7 shows that in 1983 21% of mothers were high school dropouts, as opposed to 18% in 2000. As the general level of education increases, individuals who drop out of high school are those who go against the norm because individuals who would have been high school dropouts before now become high school graduates. That is, high school dropouts are increasingly negatively selected. In turn, those who would have been high school graduates before become college graduates now. The trend of college graduates increased steadily over the sample years. In 1983 only 16% of mothers graduated from college; in 2000, the percentage reached 26%. In other words, college graduates are increasingly less-favorably selected. Therefore selection at the top overestimates convergence, while selection at the bottom gives an underestimate of convergence. To the extent that the difference in outcomes between high school and college graduates is relatively small, this will not significantly decrease the average for the college graduate group. However, it is an empirical question as to whether my evidence of a closing gradient provides a lower or upper bound on the convergence of health outcomes when using relative education groups.

To overcome these selection issues, I adopt a propensity score method. The objective is to hold constant the probability that someone goes to college, given their characteristics. I first estimate a logistic equation predicting the probability of people going to college for in 1983. Next I take the 1983 coefficients and estimate the probability of going to college for the rest of the sample years. Finally, in each year, I take the top 20% of the people as the high education group and bottom 20% of the people as the low education group. I then re-estimate model (1) using this new education group variable.

Table 5 shows the infant health gradient using these relative education groups. The results from Table 5 show the same pattern of convergence as before (i.e., using high school dropout versus college graduate); that is, we still see convergence in low Apgar scores but not in infant death rates. The interaction terms of a linear time trend and education levels are negative and significant (by chance the estimated coefficient -0.00166 is exactly the same as it is in Table 2), indicating that the differences in low Apgar scores have decreased since the early 1980s. In summary, the results in this section show that the convergence in low Apgar score shown in Table 2 is robust to possible selection issues.

7.2 Convergence by Demographic Group and by Region

Since we see convergence for the nation as a whole, it is perhaps of interest to see whether the convergence is restricted to some regions or to some ethnic groups. The convergence pattern is the same for all ethic groups, i.e., white, black and Hispanic. (Results are not shown.) However, the rate of convergence is faster in the south than in other regions (i.e., the non-south).

Table 6 shows the evolution of the gradient by region. Columns 2 and 3 show the convergence in the South[19] and the non-South areas, respectively. The coefficient of the interaction term between low education and a linear time trend for the South is -0.195 percentage points while the coefficient for the non-South is -0.160 percentage points, indicating a faster convergence in the South. If we focus on columns 5 and 6 where I restrict the sample period from 1989 to 2000, we also see that the South converged faster than the non-South. The estimated effect of convergence is -0.232 for the south, while it is only -0.141 for the non-South. Overall, the estimated coefficients show that the effect in the non-South is much smaller than in the South.

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[19] The South includes the following three census regions: West South Central, East South Central and South Atlantic. West South central include Texas, Oklahoma, Arkansas, Louisiana. East South Central includes Mississippi, Alabama, Tennessee and Kentucky. South Atlantic includes Florida, Georgia, South Carolina, North Carolina, Virginia and West Virginia.

A natural question to ask is why the gradient in the South converges faster than the gradient in the non-South. A possible answer to this question is that the Medicaid expansion was much more important in the South than in the non-South. Figure 10 supports this hypothesis; it shows the percentage of mothers who have adequate prenatal care over time by region and by maternal education. From this graph we can see that although the percentage of women having adequate prenatal care has been increasing over time in both regions, the percentage increases more rapidly for low educated women in the South. Before 1990, low educated women in the South had, on average, less adequate prenatal care than their counterparts in the non-south. However, after 1990, low educated women in the South actually had a higher probability of adequate prenatal care than their counterparts in the non-South. The timing of the rapid increase in adequate prenatal care among low educated women in the South corresponds exactly with the rapid Medicaid expansion of the late 1980s and early 1990s. Moreover, Medicaid expansion is more important in the South than in the non-South because the South is poorer. Low educated mothers in the South are, on average, poorer than the low educated women in the non-South. Therefore, more low educated mothers are covered by Medicaid in the South than in the non-South.

I also looked at differences by region for all my control variables. However, I do not see any difference in the slope of the time trend (with the exception of the adequate prenatal care variable as discussed above).

Table 7 shows the decomposition results by region. For comparison, Column 1 displays the results for the whole nation as in Table 4. Columns 2 and 3 are the decomposition results for the South and for the non-South, respectively. From the table we see that access to medical care accounts for 40% of the closing gradient for the whole nation; however, the regional differences are quite stark. Access to medical care accounts for 65% of the closing gradient in the South, but only 25% of it in the non-South, further supporting the key finding of this section – the faster rate of convergence in the South is due to the relative importance of Medicaid expansions.

8. Discussion and Conclusions

Using Vital Statistic Data in America from 1983 to 2000, I examine two important questions regarding the evolution of the inequality (or gradient) in infant health over time. First, has the infant health gradient increased or decreased over time? After finding that the gradient indeed decreases over time, the next step asks what accounts for the decreasing gradient. This study represents a first attempt to look into the evolution of the infant health gradient. The major findings of this paper are that when this disparity is measured by low Apgar scores, we observe a narrowing of the gradient over the last two decades of the twentieth century, but when using infant death rates as a measure, the gradient has remained relatively constant over time. These findings provide a sharp contrast to the literature on adults that shows increasing health disparities.

To address the second question, I use a simple decomposition which reveals that increasing access to medical care is the dominant factor in explaining the decrease in the infant health gradient, as measured by a low Apgar score. All else equal, the greater likelihood low educated women now have access to proper medical care narrows the low Apgar score gap by 39%. However, even though increasing medical care is the most important factor, it explains less than half of the closing gradient. Maternal behavior changes and demographic changes contribute significantly; maternal behavioral changes explain 29% and demographic changes, especially the increasing share of births to foreign-born Hispanics, explain 12%. When I re-analyze the results by region, I find that access to medical care is more important in the South than in the non-South. This finding is consistent with the fact that over time, the percentage of mothers receiving adequate prenatal care increases more rapidly in the South than in the non-South. Taken together, these findings suggest that the Medicaid expansion was more important in the South than in the non-South regions and that this drives the more rapid convergence of the gradient in the South.

Finally, this paper calls attention to the fact that the gradient converges not only because infant health among low education groups has increased but also because infant health among the high educated group has deteriorated in some respects. The increasing trend of multiple births among highly educated mothers is worsening the infant health distribution at the high end of the distribution.

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Appendix

In Table 2, I use a linear time trend to estimate whether the education-based infant health gap decreased over time. We see that infant health as measured by a low Apgar score has decreased; however, infant health as measured by infant death has stayed constant over time. The linear time trend, however, may mask the effects of different years. In order to check the robustness of a linear time trend, I estimate the same model using a full set of year dummies.

The marginal effects of education*year dummies are plotted in Appendix Table 1. The line with triangles (circles) plot the marginal effects of low (middle) education dummy * year dummies from 1984 to 2000. The omitted year category is 1983. The red line is a horizontal line representing 0. The difference between the line with circles (triangles) and the red line measures the degree to which the gradient has converged between high and low (middle) educated women. For example, the coefficient for low education* year1999 dummy is -0.02, which means that a baby born to a low educated mother in 1999 is 2 percentage points less likely to have a low Apgar score than a baby born to a low educated mother in 1983. Since the gap between the blue and red lines has increased over time, the gradient has decreased. Combined with the regression results using a linear time trend, we see that the decreasing gradient is robust to using a linear time trend specification or a full set of year dummies. Figure 1b in the Appendix plots the same results as Figure 3a but for infant deaths. Since the gap between the green line and the red line is basically zero, consistent with previous regression results from Table 2, this graph shows that the gradient has stayed relative constant over time and that the results are robust to using a linear time trend or a full set of year dummies.

Table 1: Summary Statistics by Maternal Education (Percentages Reported)

Variables	Low Education	Middle Education	High Education
Infant Outcomes			
Infant Death	1.32	0.85	0.54
Low Apgar Score	12.07	10.90	9.48
Maternal Behaviors			
Multiple Births	2.01	2.49	3.27
Mom Smokes during Pregnancy	28.33	16.46	3.05
Weight Gain less than 15 Pounds	10.02	8.04	4.30
Weight Gain greater than 60 Pounds	3.15	2.67	1.48
Teenage Mother	40.54	7.96	0.00
Maternal Age over 40	0.76	1.07	2.65
Married Mother	42.36	73.54	95.36
Demographic Variables			
Hispanic	15.79	5.35	2.79
African-American	26.84	17.99	7.08
White	53.84	73.78	85.52
Other Races	3.53	2.89	4.61
Foreign-Born Mother	15.44	7.75	10.69
Access to Medical Care			
Adequate Prenatal Care	49.47	72.22	85.42
Inadequate Prenatal Care	13.65	4.81	1.37
observations	874,774	2,632,968	904,444

Note:

1. Data are from U.S. Vital Statistics, 1983 to 2000.
2. Low Education: less than 12 years of schooling completed; Middle Education: 12 to 15 years of schooling completed; High Education: 16 or more years of schooling completed.

Table 2: The Effects of Education on Infant Health (Logistic Marginal Effects)

	(1)	(2)
	Low Apgar Score	Infant Death
Low Education	0.04012	0.00683
	[0.00256]**	[0.00043]**
Middle Education	0.02014	0.00252
	[0.00178]**	[0.00028]**
Time Trend * Low Education	-0.00166	0.00003
	[0.00012]**	[0.00003]
Time Trend * Middle Education	-0.00068	0.00011
	[0.00008]**	[0.00002]**
Year Trend	-0.00096	-0.00031
	[0.00018]**	[0.00002]**
Constant	-0.2071	-0.04009
	[0.00229]**	[0.00095]**
Observations	4,357,908	3,667,295

Notes:

1. Robust standard errors in brackets.
2. Regressions do not include any controls. (unconditional regressions)
3. * Significant at 5%; ** Significant at 1%

Table 3: The Effects of Maternal Education on Infant Health (Logistic Marginal Effects) With Control Variables Reported

	(1)	(2)	(3)	(4)
	Low Apgar Score 1983~2000	Infant Death 1983~2000	Low Apgar Score 1989~2000	Infant Death 1989~2000
Low Education	0.0233	0.00263	0.02025	0.00032
	[0.00224]**	[0.00035]**	[0.00286]**	[0.00052]
Middle Education	0.01419	0.00083	0.01142	-0.00028
	[0.00164]**	[0.00024]**	[0.00205]**	[0.00040]
Year Trend * Low Education	-0.00131	0.00008	-0.00117	0.00012
	[0.00014]**	[0.00003]**	[0.00021]**	[0.00004]**
Year Trend * Middle Education	-0.00062	0.0001	-0.00046	0.0001
	[0.00008]**	[0.00002]**	[0.00014]**	[0.00003]**
Year Trend	-0.00115	-0.00031	-0.0001	-0.00025
	[0.00017]**	[0.00002]**	[0.00020]	[0.00002]**
Adequate Prenatal Care	-0.01206	-0.00277	-0.00917	-0.00186
	[0.00123]**	[0.00012]**	[0.00129]**	[0.00012]**
Inadequate Prenatal Care	0.00791	0.00146	0.00926	0.00105
	[0.00104]**	[0.00014]**	[0.00103]**	[0.00018]**
Blacks	0.00918	0.00377	0.00703	0.00305
	[0.00308]**	[0.00017]**	[0.00278]*	[0.00014]**
Hispanics	-0.00788	-0.00052	-0.00847	-0.00035
	[0.00514]	[0.00026]*	[0.00439]	[0.00022]
Other Races	-0.00439	0.00089	-0.00528	0.00054
	[0.00245]	[0.00039]*	[0.00223]*	[0.00034]
Foreign-Born Mother	-0.01398	-0.0017	-0.01191	-0.0011
	[0.00305]**	[0.00024]**	[0.00290]**	[0.00022]**
Married Mother	-0.01251	-0.00171	-0.01115	-0.00115
	[0.00072]**	[0.00017]**	[0.00080]**	[0.00013]**
Multiple Births	0.11415	0.01266	0.10957	0.01055
	[0.00283]**	[0.00032]**	[0.00274]**	[0.00026]**
Teenage Mother	0.00683	0.00032	0.00824	0.00092
	[0.00093]**	[0.00015]*	[0.00099]**	[0.00013]**
Maternal Age over 40	0.01873	0.00188	0.01614	0.00101

	[0.00164]**	[0.00032]**	[0.00165]**	[0.00033]**
Weight gain less than 15 pounds			0.03141	0.00743
			[0.00100]**	[0.00023]**
Weight Gain equal to or greater than 60 Pounds			0.00426	-0.00318
			[0.00126]**	[0.00048]**
Smoking			0.00009	0.00153
			[0.00104]	[0.00013]**
Constant	-0.18433	-0.03221	-0.19217	-0.02716
	[0.00235]**	[0.00064]**	[0.00342]**	[0.00063]**
Observations	4,357,908	3,667,295	2,964,046	2,246,274

Notes:

1. Data from U.S. Vital Statistics, 1983 to 2000.
2. Robust standard errors in brackets.
3. * Significant at 5%; ** Significant at 1%

Table 4: Decomposition Results

	Total		*Changes in Characteristics*		*Changes in Coefficients*	
			Term(a)	**Term(b)**	**Term(c)**	**Term(d)**
Adequate Prenatal Care	**37.0%**		9.4%	-4.9%	14.4%	18.1%
Inadequate Prenatal Care	**2.5%**		4.9%	-2.9%	3.0%	-2.6%
Total Effects of Access to Medical Care		***39.5%***				
Mom Black	**4.8%**		4.3%	-1.0%	3.3%	-1.8%
Mom Hispanic	**-5.9%**		1.9%	4.4%	9.1%	-21.5%
Mom Other Races	**1.0%**		-1.6%	-0.1%	1.7%	0.9%
Mom Foreign-Born	**12.1%**		3.4%	4.2%	2.6%	1.8%
Total Effects of Demographic Changes		***12.0%***				
Mom Married	**12.1%**		-5.7%	4.1%	7.7%	6.0%
Multiple Births	**11.1%**		11.3%	-0.4%	-1.5%	1.6%
Weight Gain <=15 Pounds	**9.9%**		0.7%	-0.3%	3.0%	6.5%
Weight Gain >=60 Pounds	**-3.1%**		-0.1%	0.2%	1.0%	-4.3%
Mother Smokes During Pregnancy	**3.6%**		1.6%	-1.2%	-2.6%	5.9%
Mom Age >= 40	**-3.4%**		0.9%	0.1%	-1.2%	-3.1%
Total Effects of Behavior Changes		***30.2%***				
Constant	**18.4%**	***18.4%***	0.0%	0.0%	0.0%	18.4%
Total	100.0%	100.0%	31.1%	2.4%	40.6%	25.9%

Table 5: The Effects of Maternal Education on Infant Health Using Relative Education Measures: Robustness Check Using the Propensity Score Method to Address Selection Issues

	(1)	(2)
	Low Apgar Score	Infant Death
Low Education	0.06133	0.00998
	[0.00377]**	[0.00045]**
Middle Education	0.02953	0.00424
	[0.00394]**	[0.00031]**
Year Trend * Low Education	**-0.00166**	**0.00004**
	[0.00026]**	**[0.00004]**
Year Trend * Middle Education	-0.00083	0.00009
	[0.00030]**	[0.00003]**
Time Trend	-0.00092	-0.00032
	[0.00027]**	[0.00003]**
Constant	-0.21598	-0.04025
	[0.00331]**	[0.00091]**
Observations	4,357,908	3,667,295

Note: I first estimate a logistic equation predicting the probability of people going to college for 1983. Second, I take the 1983 coefficients and estimate the probability of going to college for the rest of the sample years. Finally, in each year, I take the top 20% of the people as the high education group and bottom 20% of the people as the low education group. I then estimate model (1) using these new education group variables.

Table 6: The Effects of Maternal Education on Infant Health by Region (South, Non-South)

Dependent Variable: Low Apgar Score	(1)	(2)	(3)	(4)	(5)	(6)
		1983~2000			1989~2000	
	All	South	Non-South	All	South	Non-South
Low Education	0.03015	0.03537	0.0288	0.03063	0.03768	0.02713
	[0.00232]**	[0.00216]**	[0.00286]**	[0.00226]**	[0.00264]**	[0.00236]**
Middle Education	0.01606	0.01948	0.01494	0.01536	0.01866	0.01411
	[0.00163]**	[0.00168]**	[0.00203]**	[0.00156]**	[0.00186]**	[0.00185]**
Year Trend * Low Education	**-0.00166**	**-0.00195**	**-0.00160**	**-0.00177**	**-0.00232**	**-0.00141**
	[0.00012]**	**[0.00020]****	**[0.00015]****	**[0.00022]****	**[0.00039]****	**[0.00024]****
Year Trend * Middle Education	-0.00068	-0.00082	-0.00064	-0.00057	-0.00073	-0.00049
	[0.00008]**	[0.00014]**	[0.00009]**	[0.00014]**	[0.00025]**	[0.00017]**
Year Trend	-0.00096	-0.00052	-0.00113	0.00023	0.00037	0.00019
	[0.00018]**	[0.00024]*	[0.00023]**	[0.00021]	[0.00037]	[0.00024]
Constant	-0.2071	-0.21125	-0.20619	-0.21244	-0.21406	-0.21258
	[0.00229]**	[0.00440]**	[0.00240]**	[0.00339]**	[0.00668]**	[0.00370]**
Observations	4,357,908	1,627,326	2,730,582	2,964,046	1,125,508	1,838,538

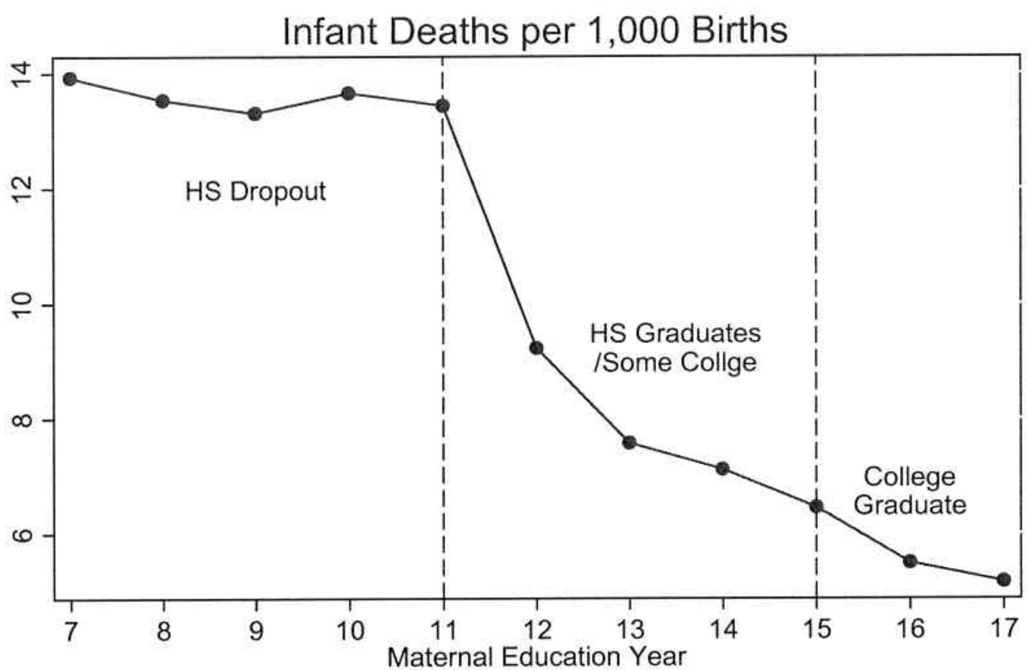
Notes:

4. Data from U.S. Vital Statistics, 1983 to 2000.
5. Robust standard errors in brackets.
6. * Significant at 5%; ** Significant at 1%.

Table 7: Decomposition Results by Region

Decomposition Results	All	South	Non-South
Adequate Prenatal Care	37.0%	64.3%	21.3%
Inadequate Prenatal Care	2.5%	2.2%	4.2%
Table Effect of Access to Medical Care	39.5%	66.5%	25.5%
Mom Black	4.8%	18.6%	-11.7%
Mom Hispanic	-5.9%	1.7%	-10.4%
Mom Other Races	1.0%	0.5%	0.2%
Mom Foreign-Born	12.1%	3.6%	14.8%
Mom Married	12.1%	43.0%	-22.5%
Multiple Births	11.1%	8.3%	14.5%
Weight Gain <=15 Pounds	9.9%	2.8%	17.5%
Weight Gain >=60 Pounds	-3.1%	-4.9%	-0.4%
Mom Smoke During Pregnancy	3.6%	6.7%	0.8%
Mom Age >= 40	-3.4%	-0.9%	-6.2%
Constant	18.4%	-46.0%	78.0%
Total	100.0%	100.0%	100.0%

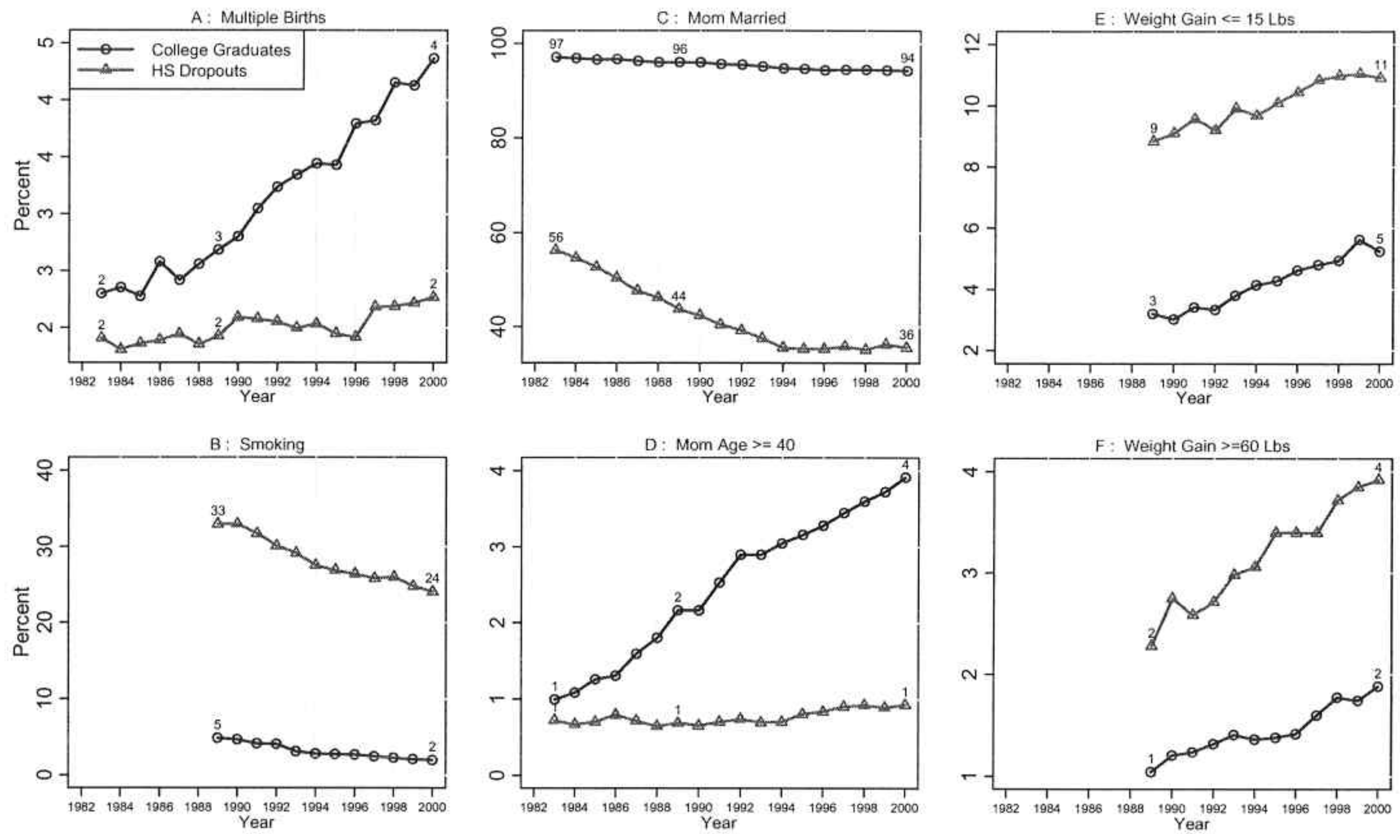
Figure 1: The Infant Health Gradient by Maternal Education



Source: Author's calculation from U.S. Vital Statistics Data 1983~2000

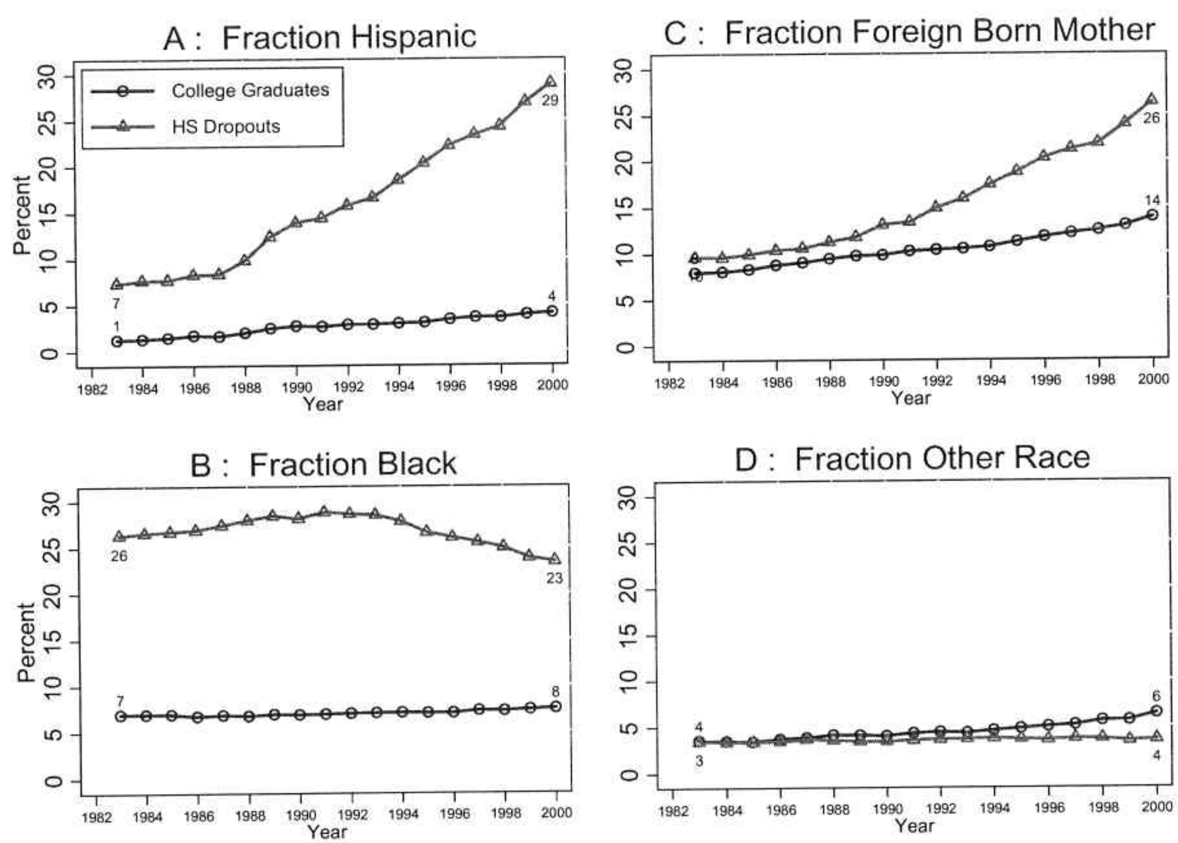
Notes: Data are from U.S. Vital Statistics, 1983 to 2000. During this period, the infant death rate is, on average, 13 per 1,000 births for women without a high school diploma while it is 5 per 1,000 births for college graduates. This figure shows that in the United States babies born to women without a high school diploma are twice as likely to die before their first birthday as babies born to college graduates.

Figure 2: Changes in Characteristics: Maternal Behavior



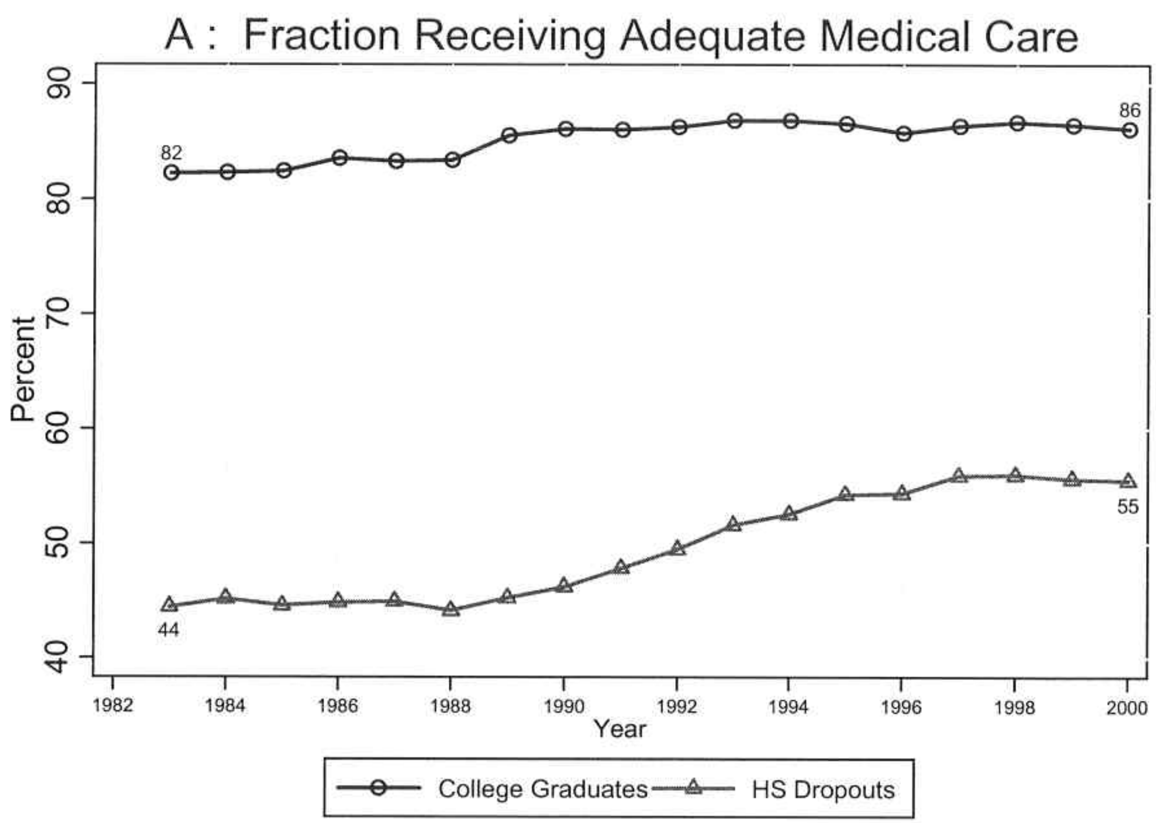
Notes: Data are from U.S. Vital Statistics, 1983 to 2000. This figure shows behavior change variables by maternal education over time.

Figure 3: Changes in Characteristics: Demographic Composition



Notes: Data are from 1983 to 2000 U.S. Vital Statistic Data. This figure shows time trends for demographic composition variables by maternal education.

Figure 4: Changes in Characteristics: Access to Medical Care



Notes: Data are from U.S. Vital Statistics, 1983 to 2000. This figure shows time trends for access to medical care by maternal education.

Figure 5a: Low Apgar Score Fractions over Time

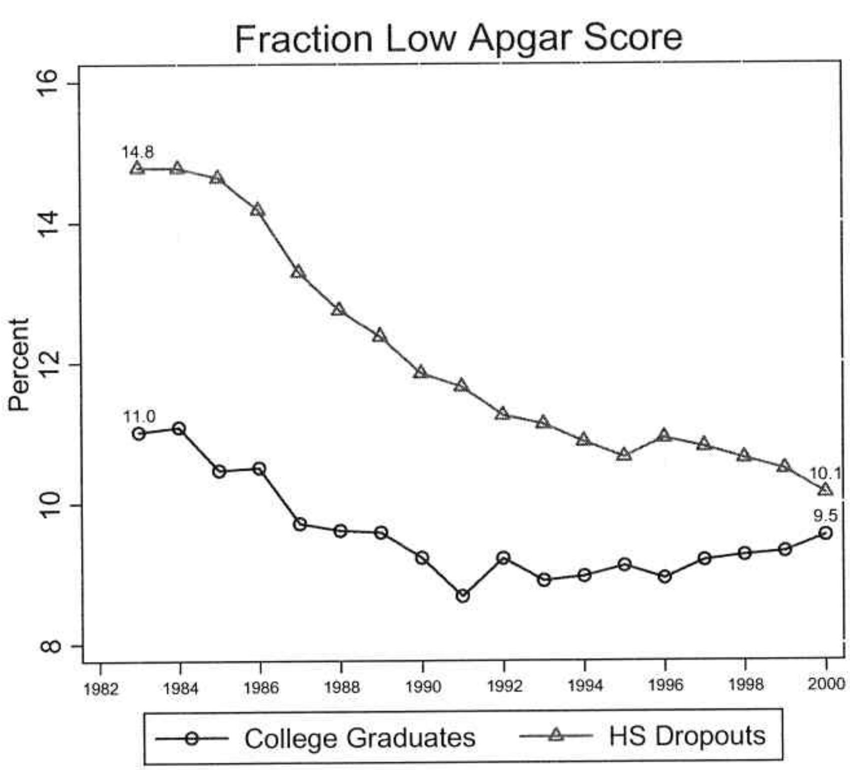
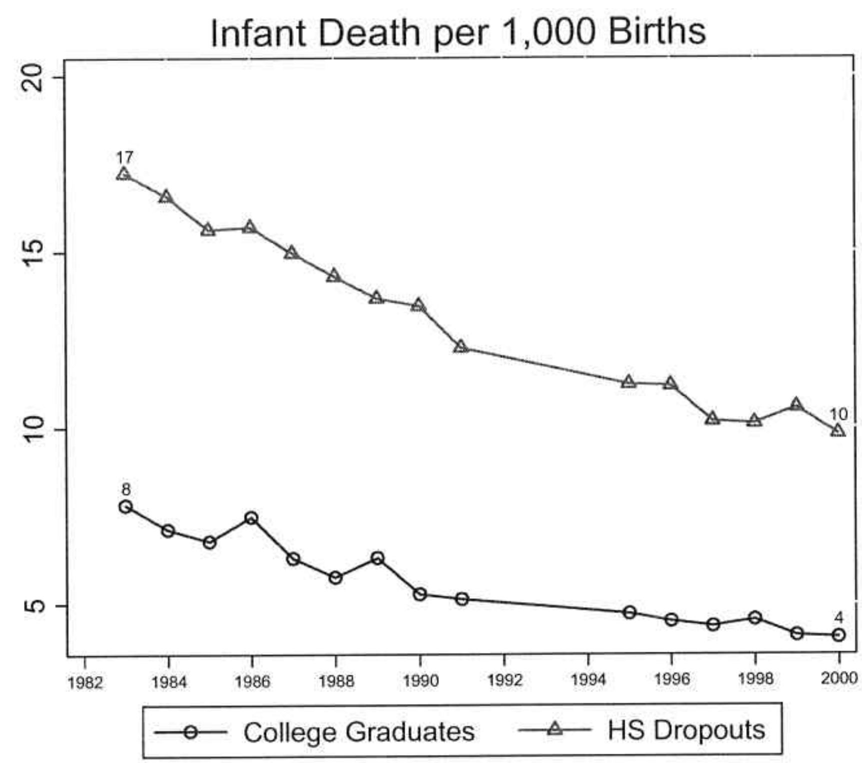
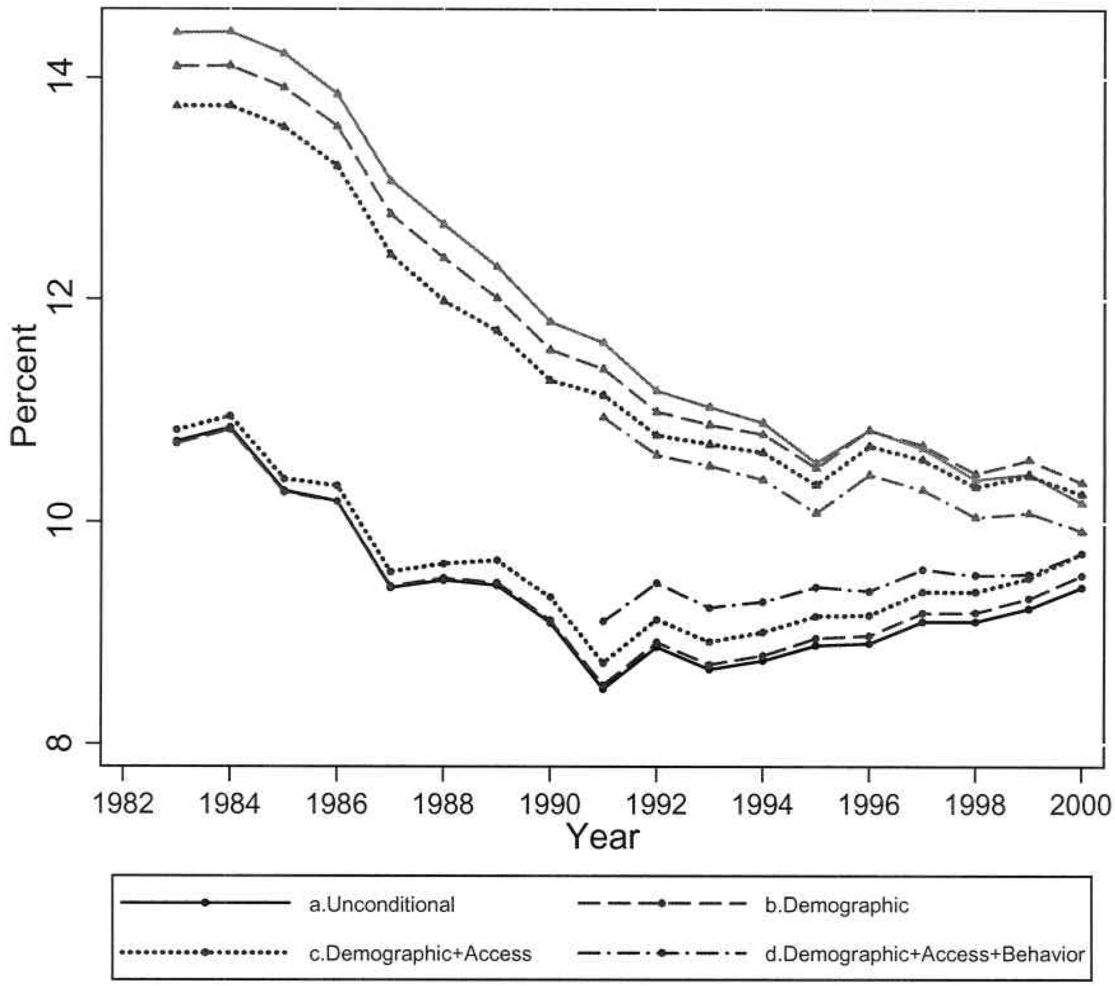


Figure 5b: Infant Death Fractions over Time



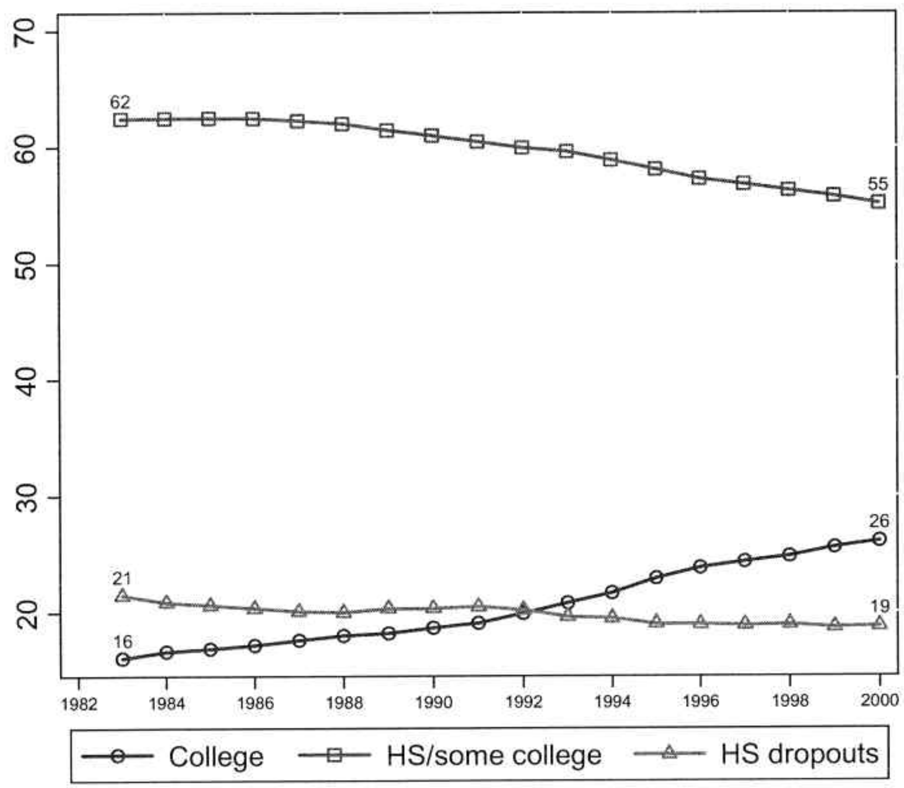
Notes: Data are from U.S. Vital Statistics, 1983 to 2000. Figures 5a and 5b plot the conditional expectation of low Apgar scores and infant death rates as a function of time by maternal education. The gradient has decreased in terms of low Apgar score and has stayed constant in terms of infant death rates.

Figure 6: Predicted Low Apgar Score with Different Sets of Control Variables



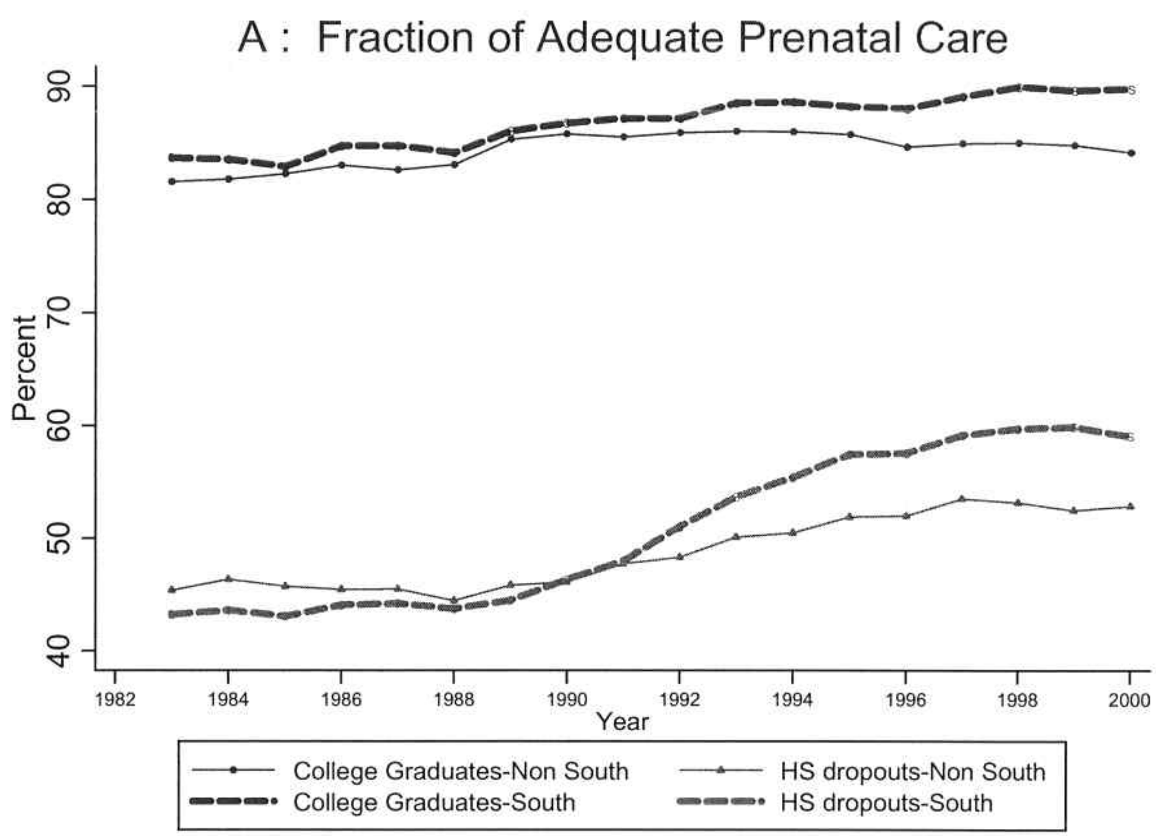
Notes: Data are from U.S. Vital Statistics, 1983 to 2000. This graph shows that when each additional set of control variable is added in the gap decreases. It plots the conditional expectation of low Apgar score for high and low education groups controlling for different sets of covariates according to the hypotheses described in section 3. The top four lines are for high education groups while the bottom four lines are for low education groups. The solid line is the unconditional expectation, which for comparison, is the same as in Figure 5a. The dashed line is the conditional expectation controlling for demographic variables. The dotted line is the conditional expectation when I control for both demographic variables and access to medical care. The dotted-dashed line is the conditional expectation controlling for all three sets of variables.

Figure 7: Fraction of Infants Born to Mothers of Different Education Groups over Time



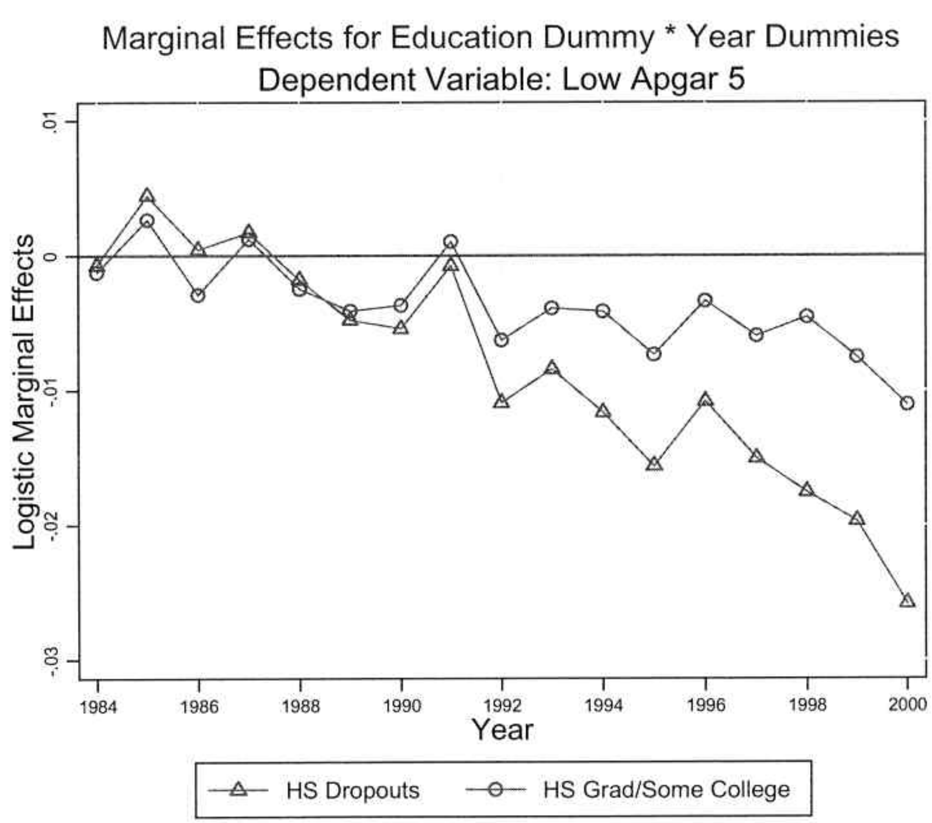
Notes: Data are from U.S. Vital Statistics, 1983 to 2000. The line with circles represents the fraction of infants born to college graduate mothers. The line with triangles represents the fraction of infants born to mothers who have high school diplomas or some college. The line with squares represents the fraction of mothers who are high school dropouts. This graph illustrates that due to the general increase in education level over time, the fraction of babies born to the high education group has been increasing while the fraction of babies born to low education group has been decreasing.

Figure 8: Access to Medical Care by Maternal Education and <u>by Region</u>



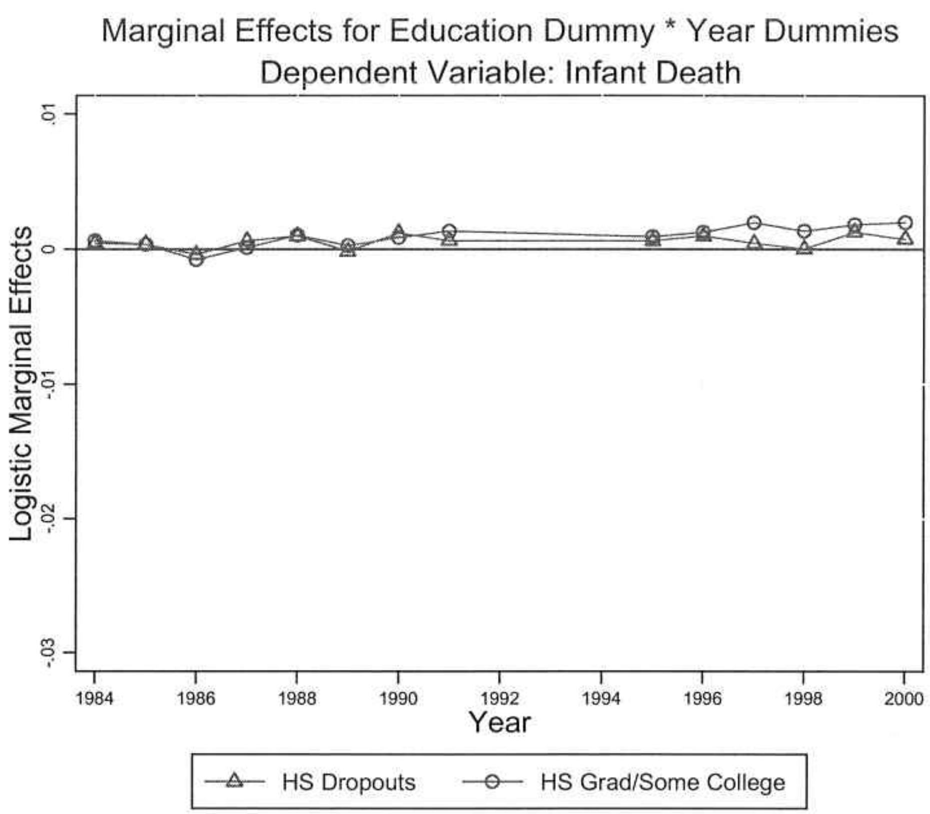
Notes: This graph shows that after 1990, the low education group in the South had more adequate prenatal care than their non-South counterpart. The timing of the increase of prenatal care coincides with the rapid Medicaid expansion in the late 80s and early 90s.

Appendix Figure 1a: Marginal Effects of Education and Year Interactions (Low Apgar 5)



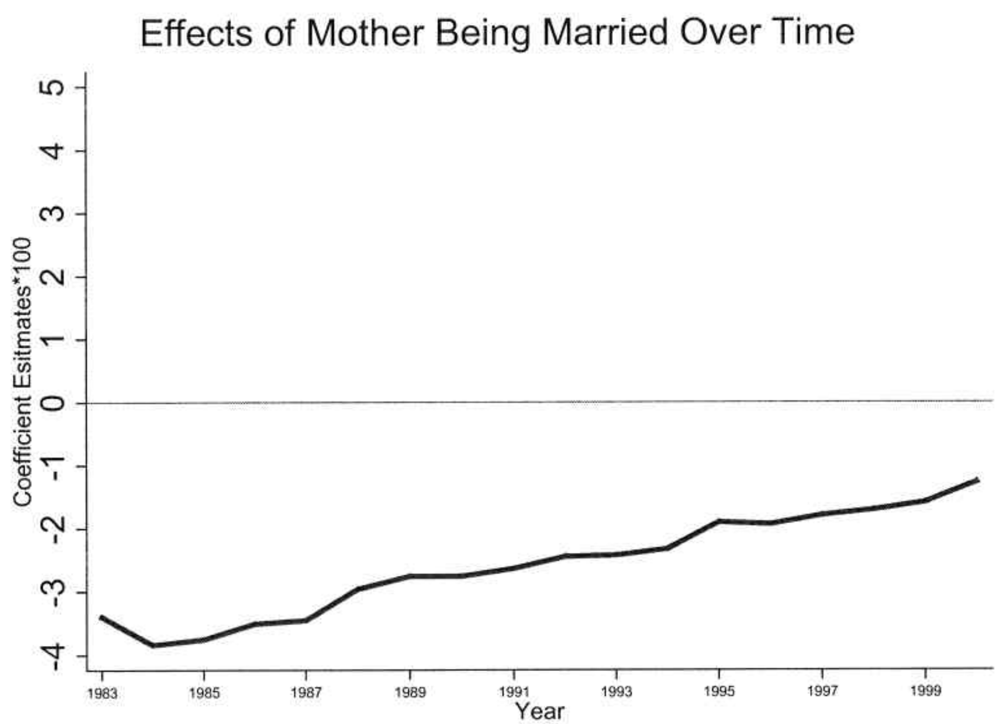
Notes: The line with triangles (circles) plots the marginal effects of low (middle) education dummy * year dummies from 1984 to 2000. The omitted year category is 1983. The red line is a horizontal line representing 0. The difference between the line with circles (triangles) and the red line measures the degree to which the gradient has converged between high and low (middle) educated women.

Appendix Figure 1b: Marginal Effects of Education and Year Interactions (Infant Death)



Notes: The line with triangles (circles) plots the marginal effects of low (middle) education dummy * year dummies from 1984 to 2000. The omitted year category is 1983. The red line is a horizontal line representing 0. The difference between the line with circles (triangles) and the red line measures the degree to which the gradient has converged between high and low (middle) educated women.

Appendix Figure 2:



Note: The effects of being married are associated with a lower return over time. For example, being married was associated with 3% decrease in low Apgar score in 1989 (base year) but was associated with only a 1% decrease in low Apgar score in 2000 (current year).

Appendix Table 1: Distribution of Apgar Scores

Apgar Score	Frequency	Percentage
0	3,016	0.07
1	8,719	0.2
2	4,276	0.1
3	4,709	0.11
4	6,817	0.16
5	12,326	0.28
6	27,749	0.64
7	70,793	1.62
8	334,017	7.66
9	3,339,701	76.64
10	545,785	12.52

Note: Data are from U.S. Vital Statistics, 1983 to 2000. A low Apgar score is defined as 8 or below, which results in approximately 10% of infants being in this category.