Mother's Education and Infant Mortality in the US: An Analysis of the Gradient by Race, Ethnicity, and Nativity

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Abstract

Infant mortality is an important indicator of the health of a nation. Compared to a set of 19 developed countries in the world, the United States (U.S.) ranks last when ranked by infant mortality (Healthy People 2010). Many researchers attribute this to the high level of inequality which characterizes the U.S. Recent work on infant mortality in the US has focused on racial/ethnic disparities, income disparities, and to a lesser extent maternal education inequalities. Social models have been used to study how social conditions such as race, socioeconomic status (SES), gender, and social support can affect multiple infant health outcomes through multiple mechanisms. Maternal SES, measured by income or education, has been found to influence infants' health outcomes not only by granting the mother access to economic resources and medical care, but also by shaping maternal health behaviors, maternal health, social networks, and exposure to environmental hazards.

In this paper I look at the maternal education gradient and how it varies across racial/ethnic groups and by nativity status of the mother. Using the 2000-2008 U.S. NCHS linked cohort birth-infant death files; I find that maternal education has a protective effect on infant health. However, a comparison across groups shows that the gradient seems to be steeper for US-born non-Hispanic whites (NHW-US), Puerto Ricans (US and foreign-born), US-born Mexicans (MEX-US), and US-born Other Hispanics (OH-US) with infants born to less educated mothers facing 30-40% higher mortality odds than infants born to highly educated mothers. No significant difference by maternal education is observed when looking at infants born to US-born non-Hispanic blacks, foreign-born Mexicans, and foreign-born Other Hispanics mothers. An analysis of the mechanisms through which maternal education affects infant health shows that maternal behaviors are the main pathway through which this occurs and this result is consistent for all groups. With the exception of MEX-US and OH-FB, maternal health is the second most important

pathway through which education affects infant mortality. Demographic factors such as maternal age of birth and marital status represent an important mediating mechanism for NHW-US.

Introduction

Infant mortality is considered to be an important indicator of population health. The past decades have been characterized by significant improvements in infant health which have been accompanied by reductions in infant mortality from 10.9 infant deaths per 1,000 live births in 1983 to a record of 5.8 infant deaths per 1,000 births in 2013 (National Center for Health Statistics 2013). Despite these declines in absolute rates, relative social disparities along socioeconomic status (SES) and racial/ethnic groups still exist and have even increased over time. Infants born to mothers with less than 12 years of schooling are approximately twice as likely to die than are infants born to mothers with 16 or more years of education (Singh and Kogan 2007; RWJF America's Health Starts with America's Children 2008). Similarly, infants born to mothers with 12 years of education (high school degree) and to mothers with 13-15 years of education (some college), have mortality rates that are 1.8 and 1.4 higher than those of infants born to mothers with 16 or more years of education (RWJF America's Health Starts with America's Children 2008).

Even though infant mortality has gone down in recent years, the US still ranks last when compared to other nineteen developed countries in this health indicator (Healthy People 2020 Report). Literature on the subject has focused both on absolute and relative disparities in infant mortality and how these have evolved over time (Frisbie 2005, Singh and Kogan 2005, Frisbie et al 2006). Parental socioeconomic status (SES), particularly maternal education, has been identified as one of the fundamental causes of these health disparities (Currie and Moretti 2003, Frisbie 2005, Finch 2010). Similarly, parental income, wealth, and job occupation have also been established to be important fundamental causes of birth outcomes (Finch 2010, Case and Paxson 2002). Moreover, research has focused on determining the different mechanisms (proximate determinants) through which maternal education affects infant mortality (Meara 2001, Singh and Kogan 2005, Finch 2010). Identifying the fundamental causes of

disparities in infant mortality and understanding the differences between fundamental causes and proximate determinants is important when designing policies addressing these inequalities. A close examination of policies in the US will show that these have targeted pathways linking education to infant health, resulting in reductions in absolute rates and increases in relative disparities. The effect of SES on health outcomes has been shown to vary across racial/ethnic groups and by nativity status. This has been captured by the Hispanic paradox which centers around the fact that even though the socioeconomic profile of Hispanic groups with regard to educational attainment, income, and health insurance resembles that of non-Hispanic blacks (NHB) , this group as a whole experiences lower mortality rates than NHB and similar or lower rates than non-Hispanic whites (NHW) across most of the life course (Elo et al 2004, Hummer et al 2004). Health selectivity, social support/ties, and culture have been posited as factors that might offset their lower socioeconomic status.

This paper argues that maternal education is a fundamental cause of infant health. Nevertheless, due to differences in the access to resources higher education leads to, the maternal education of infant mortality is expected to vary across racial/ethnic groups and by nativity status. The analysis is stratified by groups in order to determine the disparities by maternal education in infant mortality and how they vary across groups. These group-specific analyses also allows for the identification of the main mechanisms through which maternal education affects birth outcomes and how these may differ based on race, ethnicity, and nativity. Given the persistent of socioeconomic inequalities in infant mortality, the wide socioeconomic disparities in the US, the unequal returns to education, and the racial/ethnic diversity of the population, accounting for variations in the gradient and mechanisms is necessary.

Background/Conceptual Framework

Infant mortality refers to the deaths that occur after a live birth and before a child reaches one year of age. Infant mortality is viewed as a measure of the health and well-being of children and the overall population health of a community. Over the past decades, significant improvements in infant health have been made with rates of infant mortality falling from 10.9 infant deaths per 1,000 live births in 1983 to a record of 5.8 infant deaths per 1,000 births in 2013 (National Center for Health Statistics 2013). Even though mortality rates have declined, substantial differences exist across socioeconomic and racial/ethnic groups. For instance, infants born to mothers with less than 12 years of schooling are approximately twice as likely to die than are infants born to mothers with 16 or more years of education (Singh and Kogan 2007; RWJF America's Health Starts with America's Children 2008). Similarly, infants born to mothers with 12 years of education (high school degree) and to mothers with 13-15 years of education (some college), have mortality rates that are 1.8 and 1.4 higher than those of infants born to mothers with 16 or more years of education (RWJF America's Health Starts with America's Children 2008). Moreover, the differences in infant mortality rates by maternal education can vary across racial/ethnic groups. This can be due to the fact that the education returns for education might be higher for some racial/ethnic groups such as non-Hispanics whites (NHW), than for other groups such as non-Hispanic blacks (NHB) and Hispanics. (read the Olshansky 2010 paper here) Additionally, while having a low educational attainment can represent a large penalty for infants born to NHW mothers; it might not have such a negative impact for infants born to Hispanic mothers especially the foreign-born group. The existence of social support, healthy behaviors, culture, and positive health among foreign-born Hispanic mothers can help offset, to a certain degree, the negative impact lower levels of education can have on infant mortality. Thus, it is important to see how the maternal education gradient varies across different racial/ethnic groups in the US.

The fundamental cause theory (FCT) provides an explanation for the persistent association between social factors and health-related outcomes (Link and Phelan 1995). The FCT states that social factors such as socioeconomic status (SES), race, gender, and social support are fundamental causes of health, disease, and mortality risk because they "embody access to important resources , affect multiple disease outcomes through multiple mechanisms, and consequently maintain an association with disease even when the intervening mechanisms change" (Link and Phelan 1995, Phelan 2004). According to the fundamental cause theory, the main reason of why SES is related to multiple disease outcomes through multiple pathways that change over time is because SES provides individuals with resources which can be used to avoid risks and take advantage of protective strategies (Link and Phelan 2010). These flexible resources operate both at the individual and contextual level. At the individual level, flexible resources can shape individual health behaviors by influencing whether people have knowledge, access to, and can afford to engage in health enhancing or health protective behaviors. Resources also shape access to broad contexts which vary in terms of risk profiles and protective factors. For instance, living in a high SES neighborhood provides individuals with a safe environment which has good health care facilities, recreation areas, and good food stores, and is also characterized by low levels of crime, noise, violence, pollution, and crime (Link and Phelan 2010). Moreover, it gives individuals living in these neighborhoods access to social connections to highly educated people which leads to knowledge about healthy behaviors.

In a comprehensive study on infant mortality, Frisbie (2005) highlighted the importance of using multilevel models when studying infant mortality since it was important to consider both individual and contextual level factors. When focusing on a micro-level analysis of infant mortality, Frisbie (2005) divided the risk factors into three main categories which were background factors, prenatal intervening factors, and postpartum/proximate factors. Consistent with the FCT, infants born to low SES mothers were more likely to be born low birth weight and were less likely to survive past the first year of life

(Hessol 1997). This was found to be due to women in this group lacking the resources to access prenatal care, postnatal care, or both, and/or to lack of health knowledge or knowledge on how to access health resources. Maternal education is the SES measure most commonly linked to birth outcomes and infant survival due to lack of other measures such as family income which are not reported in the vital statistics (Hummer, Eberstein, and Nam 1992). Empirical work has found that the positive effect of maternal education on infant mortality persists after adjusting for different risk factors (Hummer et al 1999).

When studying infant mortality in the United States, it is important to acknowledge that infant mortality or survival is influenced by socioeconomic, environmental, behavioral, maternal health, and health care factors (Frisbie 2005). Social disparities have resulted in an unequal distribution of the risk factors which has given rise to significant differences in mortality rates across socioeconomic groups. Even though infants born to socioeconomically disadvantaged mothers are exposed to a higher risk of death, it is important to consider that this negative association might vary across racial/ethnic/nativity subpopulations. For instance, even though non-Hispanic blacks (NHB) and Hispanics populations in the US have achieved socioeconomic gains in the past decades, substantial inequalities in educational attainment, income, occupational prestige, wealth, health insurance coverage, and access to health care information still exist (Smelser 2001). Nevertheless, even though infants born to Mexican origin women are disadvantaged when compared to NHWs due to the low socioeconomic status of their families, their mortality rates are similar or better than the rates of infants born to NHW mothers (Hummer et al 1999, Hummer et al 2007). In this case, the favorable distributions of behavioral and maternal health risk factors of Mexican origin women compared to NHW and NHB women help compensate for their socioeconomic disadvantages resulting in an overall Mexican origin infant mortality rate that is similar to that of infants born to NHW women (Hummer 1993, Hummer et al 1999, Hummer et al 2007). This is especially the case for infants born to Mexican immigrant women who are characterized for having IMRs that are lower than that of infants of Mexican American origin and substantially lower than the rates for

black infants (Hummer et al 2007). These more favorable mortality outcomes for Hispanics relative to non-Hispanic whites in the US are consistent with the Hispanic Health paradox (HHP) which states that even though the socioeconomic profile of some Hispanic groups with regard to educational attainment, income, and health insurance coverage closely resembles that of NHB, this group consistently experiences lower mortality rates than NHB and equal or betther than NHW (Markides and Coreil 1986, Hummer et al 2007,Turra and Elo 2008). Explanations for the infant mortality paradox have focused on immigrant selectivity (Franzini et al 2001, Markides and Eschbach 20050, the positive role of Hispanic culture (Franzini et al 2001), and data quality (Hummer et al 2007,Turra and Elo 2008). Lower rates of smoking and alcohol use, better nutrition, and stronger family ties when compared to NHW have been identified as protective cultural attributes (Williams 1986). Mexican-origin women who have maintained Mexican-oriented cultural values, beliefs, practices, and lifestyles have been found to experience lower rates of low birth weight than their counterparts with a US orientation which provides support for the acculturation hypothesis (Cobas et al 1986).

Thus, when looking at the effect of socioeconomic status on infant health, it is important to consider that the magnitude and prominence of SES can vary across the different racial/ethnic/nativity groups in the US depending on access to resources that higher SES provides to different groups, the composition of the population, and the distribution of maternal risk factors which can buffer the negative effect of a low educational attainment. Racial/group membership can partially moderate the role that education and socioeconomic status play in influencing health disparities for each of the groups. Trends in life expectancy at birth within the four educational categories have shown that there exist within group disparities with people with sixteen or more years of education living longer than people with less than high school. Disparities across groups still persist with members of racial minorities (NHB) with high levels of education having a shorter life expectancy than NHW with the same level of education. Moreover, Hispanic females did not experience rising longevity among those with a high school

education or higher contrary to females from other groups. Similarly, NHW with less than a high school education have experienced a consistent pattern of decreasing longevity, while NHB and Hispanics with the same education have exhibited increasing longevity (Olshansky et al 2010). This illustrates how education, and SES for that matter, affects racial/ethnic groups differently which justifies why when looking at the maternal education gradient on infant mortality, we should also look at how this gradient varies across groups.

Singh and Kogan (2005) showed that even though there were dramatic declines in infant mortality among all of the socioeconomic groups during the 1969-2001 period in the US, substantial socioeconomic disparities persisted in overall, neonatal, and postneonatal mortality. Relatively larger declines in mortality among the higher socioeconomic groups have contributed to the widening gap in infant mortality since 1985. Compared to infants born to mothers with ≥16 years of education, the adjusted risk of overall mortality for infants born to mothers with <12 years of education was of 41% in 2001 compared to 22% in 2001. Disparities were greatest among normal birth weight infants, with education-specific relative risks of neonatal and postneonatal mortality increasing significantly between 1986 and 2001. The existence of persistent disparities in infant mortality may reflect polarization among socioeconomic groups in other social, behavioral, and health care factors such as smoking and health care services. Nevertheless, SES differences in infant mortality remained after controlling for risk factors especially for the more recent cohorts. This indicates that maternal education is an important predictor of infant survival. Similar results were found when trends in infant mortality were analyzed by using an area deprivation index.

Research focusing on maternal education and the intergenerational transmission of human capital has also looked at other infant health outcomes such as birth weight and gestational age (Currie and Moretti 2003). Using Vital Statistics Natality data, they found that higher maternal education improves infant

health as measured by birth weight and gestational age. When looking at the channels through which maternal education may improve birth outcomes, higher maternal education was found to be associated with a higher probability of being married, a reduction in parity, an increased use of prenatal care (PNC), and a reduction of smoking, suggesting that these can be important pathways to consider. Educational attainment provides educated mothers with higher status jobs, higher incomes, access to health insurance, proper diet, and life in non-toxic environments, all of which matter for infant health (Finch 2003, Currie and Moretti 2003, Strully et al 2010, Currie et al 2011). Nevertheless, the estimates of the returns to maternal education on infant health can be understated if they focus solely on higher wages as the only pathway, neglecting other channels such as health behaviors, cognitive skills, and knowledge which are also beneficial. There is substantial evidence of a relationship between education and health-promoting behaviors such as alcohol consumption and smoking (Currie and Moretti 2003, Cutler and Lleras Muney 2010), both of which are associated with birth outcomes particularly low birth weight (Kleinman et al 1988, Chen et al 2009). Similarly, education allows mother with the knowledge on how to better access the health care system and how to follow treatments (Goldman and Smith 2002, Hummer et al 1999).

Studies have found that parental behavior and socioeconomic status affect children's health (Case and Paxson 2002). The role that parental resources and behaviors have in children's health is evident in the large socioeconomic disparities in children's health outcomes which increase throughout childhood. Even though it is common to conclude that these disparities are due to differences in access to health insurance and health care, medical care might not be the main pathway through which SES affects health outcomes. It is well known that the behavior of parents is correlated with socioeconomic status and can be important when explaining the association between children's health and SES. In the case of the health status of infants at birth, several factors such as the health and nutritional status of the mothers, the medical care they receive during pregnancy, and their use of substances have been shown

to result in poor birth outcomes. More specifically, behavioral factors such as the use of tobacco, alcohol, and illegal drugs during pregnancy adversely affect the health of newborns. Hans (1999) showed that the use of these substances during pregnancy is more common among poorer and less well educated women, which implies that they can be key factors in explaining the existent socioeconomic gradient in infant health. Using data from the National Maternal and Infant Health Survey (NMIH), Meara (2001) finds that up to half of the socioeconomic disparities in birth weight for white children, and one third for black children, can be explained by smoking behaviors. Thus, maternal behaviors more than access to health care (talk a little about inequality after Medicaid), appear to be a more important mechanism through which SES affects birth outcomes. Meara (2001) finds that differences in health habits between college-educated and other women, although largely determined by higher investments on health by high SES women, are also explained by high SES women having more complete health knowledge and a better response to common health knowledge relative to low-SES groups. Furthermore, these disparities in health habits, particularly smoking, are found to exist since early in life and have little to do with smoking cessation during pregnancy. Aside from income and education, "third variables" such as health knowledge and network effects at the family level determine much of the disparities in health behaviors early in the lives of women suggesting that policies should target inequalities in the youth period more so than during pregnancy.

Recent empirical research on the early origins of the SES gradient for infant mortality in the US found that absolute material conditions are the most important determinants of socioeconomic effects on the risk of infant mortality, and that while poverty has the most pronounced effect on risk, income is decreasingly salutatory across the majority of the mortality gradient (Finch 2010). Additionally, traditional risk factors for poor birth outcomes were found to be highly correlated with SES as measured by income and with maternal education. Among the risk factors, parity and insurance status of mothers

represented the largest mediators of the income-infant mortality relationship. These results were found to be consistent when looking at all-cause, endogenous, and exogenous infant mortality.

Advances in health care technology, despite reducing absolute infant mortality rates for all groups, have increased social disparities (Gortmaker and Wise 1997). Looking at infant mortality patterns in the US for the period 1950-1993, they found that even though there were significant reductions in absolute rates, social disparities in infant mortality still existed. This was explained to be the consequence of rapid improvements in health services technology surrounding childbirth and is consistent with the FCT which states that when technological advances occur, the most advantaged group will be the one accessing the new technology (Link and Phelan 2010) widening relative disparities.

Multiple studies have looked at the link between maternal education and birth outcomes. Overall, they have established that maternal SES has a protective effect on infant mortality. Given the importance of maternal SES for infant health, a thorough analysis of the maternal education gradient is justified. Moreover, given how the effect of education varies across racial/ethnic boundaries, an analysis broken down along these lines is necessary.

Research Questions

Given the importance of maternal education for infant mortality, this study tries to answer three main questions: 1) What is the maternal education gradient of infant mortality and how does the magnitude vary across racial/ethnic groups? 2) What are the main pathways through which maternal education influences infant mortality and how do they vary across racial/ethnic groups/ 3) Using counterfactual scenarios, what would be the excess mortality rate if we were to assign lower educated women higher education levels?

The main contribution of this research is that even though there has been work on the maternal education on infant mortality, the focus has been on all births in general or limited to births of non-Hispanic whites and blacks. In this paper, I extend the analysis to include other racial groups such as Hispanics (Mexicans, Puerto Ricans, and Other Hispanics) broken down by nativity status. Given the differential access education has for different groups, and the existence of factors such as social support and health selectivity which can offset the negative impact of a low educational attainment, a group-specific analysis of the gradient is appropriate.

Data and Methods

Data

This analysis uses data from the National Center for Health Statistics (NCHS) linked birth/infant death cohort files for the years 2000-2008. Even though public data for the year 2006 is available, the restricted data which allows us to determine the country of origin of the mother is not available. As a result, this year is excluded from the analysis. Given the scope of this study, the data will include all infants born alive to U.S.-born non-Hispanic whites (NHW-US), U.S.-born non-Hispanic black (NHB-US), U.S. and foreign-born Mexican women (MO-US, MO-FB), U.S.-and foreign-born Puerto Rican-women (PR-US,PR-FB), and U.S. and foreign-born Other Hispanic women (Other Hispanic-US, Other Hispanics-FB). This leaves us with a set of 8 cross-sectional NCHS records which gives us a total of 30,094,534 live births and over 173,420 deaths for the period and racial/ethnic/nativity groups under consideration. Asians, both US and foreign-born, Pacific Islanders, American Indians/Alaskan Natives, FB-NHW, and FB-NHB are excluded from the analysis due to small numbers, high selectivity, and to focus the analysis on racial minorities groups such NHB and Hispanics relative to US-NHW. The match rate of births with infant deaths was exceptional, with more than 98% of the records successfully linked for each of the years under analysis (DHHS 2000-2008). In order to determine the race and ethnicity of the infant, I use the maternal racial/ethnic/nativity reported on the certificate as has been done previously in the literature (Hummer 1993, Hummer et al 1999, Powers 2013). Infants for whom the race, ethnicity, or nativity could not be determined due to missing information on either of the categories were excluded from the analysis.

Variables

The key dependent variable in this analysis is overall all-cause infant mortality. A dummy variable is used to indicate whether an infant died during his first year of life (coded 1) or if the infant lived past his first

birthday (coded 0). It is worth noting that we are looking at overall infant mortality without breaking it down into neonatal and post-neonatal infant mortality. This more specific analysis merits a separate paper which is in progress.

The analyses use a set of demographic, socioeconomic, maternal health risk factors, and maternal behavioral factors. The key independent variable is maternal education which is used as an indicator of the socioeconomic status (SES) of the mother. Maternal education is highly important for birth outcomes since it can affect the infant's health through multiple pathways such as higher income, better access to health insurance, increased health knowledge, better cognitive ability, and less risky health behaviors (Currie and Moretti 2003, Cutler and Lleras Munery 2009, Finch 2010, Frisbie 2005). Maternal education is measured as a categorical variable where less than high school diploma, high school diploma, some college, and college degree and higher represent the main categories. From 2003 onwards, the NCHS included an additional variable for education which breaks some college into some college but no degree and associate's degree, and college or more into bachelor's, master's, and doctorate degree. Nonetheless, I used the standard maternal education variable since it allows me to extend the analysis to years previous to 2003 and is still consistent across the different years.

Demographic characteristics included race/ethnicity, maternal age, marital status, and parity. Using the race/ethnicity of the mother, infants are identified as being non-Hispanic whites (NHW), non-Hispanic black (NHB-US), Mexican (MEX), Puerto Rican (PR), and Other Hispanic (Other Hispanic), each of which is further broken down by nativity status. Since the goal of the paper is to determine if and how the maternal education and the pathways from maternal education to infant health vary across groups, the analysis is stratified by race, ethnicity, and nativity. In the multivariate analyses, maternal age is a categorical variable where 18-20, 21-24, 25-34 (reference), and 35-50 are the age groups under consideration. Since the main goal is to look at the effect of maternal education on birth outcomes,

mothers who gave birth at ages 17 and younger should be excluded because they have very low level educations and are not expected to have a high school degree. The other categories are based on ages at which different educational levels should have been attained and on different risks mothers might face. For instance, mothers ages 18-20 should have a high school degree and not having one can be problematic. On the other hand, mothers who gave birth at ages 35 and older should have completed college by then and not having one could adverse health outcomes. Moreover, women in this age group might experience different mortality risks relative to women in other age groups (i.e. 25-34) even after controlling for education because they face higher mortality risks from certain causes of death. Sex of the infant is measured as female (reference) or male. Marital status is a dummy variable indicating whether the mother was married at the time of the birth (reference) or single. The data does not allow us to tell if the mother is cohabiting or not. Parity is a categorical variable indicating whether Live birth order is a variable indicating whether it was the first live birth, second or third live birth (reference category), or the fourth or higher live birth. In future revisions of the paper, a measure of parity will replace live birth order. Parity, which is operationalized by using the Kleiman and Kessel index (1987), takes into account the interactions between birth order and maternal age (first birth, low parity, high parity) resulting in a more accurate indicator than live birth order.

Maternal health/biological risk factors include maternal morbidity and labor complications, both of which are recognized as proximate determinants of birth outcomes and infant mortality (Frisbie 2005). Maternal morbidity is a dummy variable coded 1 if the mother responded positively to having at least one of the following: anemia, cardiac disease, acute or chronic lung disease, diabetes, genital herpes, chronic hypertension, hypertension, eclampsia, incompetent cervix, previous infant weighting 4,000 g or more, renal disease, Rh sensitization, uterine bleeding, and other medical risk factors, and 0 if they did not have any (reference). Labor complications is a dummy variable coded 1 if the mother responded positively to having any of the following: febrile, meconium, premature rupture of membrane, abruptio

placenta, placenta previa, other excessive bleeding, seizures during labor, prolonged labor, dysfunctional labor, cord prolapsed, anesthetic complications, fetal distress, and other complications of labor and/or delivery.

Maternal behavioral risk factors include prenatal care, weight gain, alcohol use, and maternal smoking during pregnancy. The Adequacy of Prenatal care Utilitzation (APNCU) Index (Kotelchuk 1994) compares the number of prenatal care visits with the expected number of visits for the period between when care began and delivery date to determine the adequacy of received prenatal care services. The APNCU index used in the multivariate analyses includes adequate prenatal care, intermediate prenatal care, inadequate prenatal care (which indicates fewer than expected number of prenatal care visits), and adequate-plus prenatal care (potentially indicating maternal health problems during pregnancy). Weight gain indicating how much weight the mother gained during pregnancy is measured as a categorical variable with 0-14, 15-24, 25-39, and 40 or more (reference) as the categories. Alcohol use is dummy coded 1 (0 otherwise) if the mother had at least one drink during pregnancy. Maternal smoking is a dummy coded 1 (0 otherwise) if the mother used tobacco during her pregnancy.

Additional risk factors such previous pregnancy loss and plural births are also included in the analysis. Pregnancy loss is coded 1 if the total number of births is greater than the total number of live births and 0 if they are equal. Plural births are coded 1 if birth was not a singleton birth (twins or higher) and 0 if it was a singleton birth.

Methods

A series of logistic regression models stratified by race/ethnicity/nativity are used to examine the maternal education gradient of overall infant mortality and how it varies across the different groups under consideration. Maternal education is the main predictor variable in these models; however, progressively adding demographic, maternal health/biological risk factors, maternal behavioral risk

factors, and other pregnancy risk factors into the models, allows for the identification of the potential pathways through which maternal education affects infant mortality. Since the models are specified for racial/ethnic/nativity group under consideration, it is possible to determine both how the maternal education gradient and the mechanisms linking education to birth outcomes vary in magnitude across groups.

Results

Based on the fundamental cause theory (FCT) and on empirical research on the determinants of infant health, we would expect maternal education to be protective of an infant's health. That is, higher levels of education should result in lower infant mortality levels to the access of resources education leads to. Similar, infants born to mothers with lower levels of education should be at higher risk of dying. Table 1 presents the maternal education-specific infant mortality ratios (rate ratios) for different levels of education relative to women with college or higher for the different racial/ethnic/nativity groups under consideration. The rate ratios show that infants born to NHW-US, MEX-US, PR (US and FB), and OH-US mothers with less than high school, high school, or some college education face a higher risk of dying when compared to infants born to mothers with a college education or higher. The risk is considerably higher for infants born to mothers with less than a high school degree. For instance, infants born to mothers with lower levels of education face a 40% to 140% higher risk of dying when compared with their college or higher educated counterparts. A similar range of risks is observed for MEX-US, PR (US and FB), and OH-US, emphasizing the significant disadvantage infants born to less educated women in these groups face. In the case of infants born to NHB-US, MEX-FB, and OH-FB, Table 1 shows that even though infants born to mothers with low levels of education are at higher risk of dying than infants born to college educated women, the excess mortality risk is not as high as for the previous groups. Compared to infants born to NHB-US college educated women, infants born to mothers with lower

levels of education have 10-30% higher risks of dying. The risk ratios are 20-30% and 20-40% higher for MEX-US and OH-US respectively. Hence, having less than a high school degree or just a high school degree is a higher penalty for certain racial/ethnic groups. Similarly, higher levels of education seem to lead to more resources and knowledge in some groups where higher levels of education are accompanied by significant reductions in infant mortality rates. In addition, it is important to note that for some racial/ethnic groups (NHB-US, MEX-FB, PR-FB, OH-US, PH-FB) the effect of having some college education on infant mortality is not different from that of having just a high school degree. That is, some college education does not seem to accrue much resources/benefits which can substantially improve birth outcomes.

[Insert Table 1 here]

Table 2 shows the educational disparities in infant mortality rates by racial/ethnic group broken down by nativity status. Overall, an increase in educational attainment of the mother is associated with substantial decreases in their infant mortality rates. The mortality rate of infants born to mothers with >=16 years of schooling is 50.6% lower than that of infant born to mothers with less than a high school degree. Nonetheless, as was established in Table 2, it can be seen that there is heterogeneity across groups regarding the effect that higher levels of education have on infant mortality rates. For instance, infants born to NHW-US mothers with >=16 years of education have 61.7% lower rates relative to infants born to mothers with <12 years. When looking at the Hispanic groups, particularly the foreign-born population, it can be seen that even though infants born to mothers with college education and higher have lower rates, these are only 18% (MEX-US) and 25% (OH-FB) lower than the rates of infants born to mothers with less than high school. Table 2 also shows the excess mortality and the index of disparity of overall infant mortality for the different racial/ethnic groups in the analysis. The excess mortality estimates in Table 2 indicate that the overall infant mortality rate for all groups combined

would have declined by 35% if the mortality rate for all the education groups were the same as the rate for infants born to mothers with a college degree or higher. While the reduction in mortality rates would have been in the range of 30-35% for infants born to NHW-US and US-born Hispanic mothers, mortality would have only declined by 21% for NHB-US and by 16% for MEX-FB and OH-FB. The index of inequality, which summarizes the magnitude of the disparities across the 4 education groups, shows that even though there are educational disparities across all groups, there is substantial diversity in the magnitude. While all groups combined, NHW-US, and OH-US have an index score ranging from 54-68%, MEX-FB and OH-FB have index scores of 13% and 17% respectively, which show that educational disparities are larger among the former groups.

This variability in the effect of education on infant health shows that education is in fact protective of health; however, there are other factors such as income, job opportunities, social support/ties, culture, and health selectivity, among others that affect the magnitude of this effect. It can be the case that the access to resources higher education gives rise to can vary across groups. It has been shown that there are disparities in the job opportunities and income that college educated women from minority groups such as NHB-US and Hispanics have compared to NHW-US (Olshanksy et al 2010, Hummer and Hernandez 2012). Similarly, the penalty of a low educational attainment on infant health is more prejudicial for HNW-US and NHB-US than for Hispanics. This is consistent with empirical studies on life expectancy which show that only Hispanic females did not experience rising longevity among those with a high school education or higher. Additionally, while NHW-US female with less than a high school education have experienced a consistent pattern of decreasing longevity, NHB-US and Hispanics have exhibited increasing longevity (Olshanksy 2010).

[Insert table 2 here]

Table 3 displays the socioeconomic differences in overall infant mortality for all the racial/ethnic groups grouped together. Compared to infants born to mothers with college or higher levels of education, infants born to mothers with less than high school, high school, and some college are at a higher risk of dying (with odds ratios (ORs) of 92%, 85%, and 43% higher respectively) in our basic model (Model 1). The higher mortality risk among infants born to mothers with low levels of education is diminished when controls for maternal age at birth, marital status, and sex of the infant are added. Less educated women are more likely to give birth at younger ages and to be single. Thus, controlling for these measures attenuates the difference in ORs between less educated women and women with college or higher levels of education. Controlling for live birth order (Model 3) and for maternal health by including measures such as pregnancy loss, maternal morbidity, and maternal labor complications (Model 4), reduces the higher infant mortality odds of infants born to mothers with less than high school, high school, and some college education. Incorporating measures of maternal behavior such as weight gain during pregnancy, smoking, alcohol use, and prenatal care (PNC), substantially reduces the infant mortality ratios of infants born to less educated mothers face 7% (less than high school), 16% (high school), and 10% (some college) higher odds relative to infants of highly educated mothers (Model 5). The final model (Model 6) which controls for SES, demographic characteristics, parity, maternal health, and maternal behavior shows that there are differences in overall infant mortality among different maternal educational levels with, but the high SES differential in OR's observed in the null model was attenuated. Infants born to less educated mothers have 20%7% (less than high school), 24% (high school), and 13% (some college) higher odds of dying than infants born to mothers with more than a college degree. Most importantly, Table 3 reveals that maternal behaviors are the main pathway through which maternal education is affecting infant mortality. A higher prevalence of unhealthy behaviors among less educated women can be a major contributing factor to the disparities in infant mortality of this group relative to that of the highly educated women.

[Insert Table 3 here]

As seen in Table 1 and Table 2, the effect of maternal education on infant mortality varies across racial/ethnic groups. This merits a race/ethnicity/nativity-specific analysis of the maternal education gradient in order to: 1) Determine how the educational gradient varies across groups and 2) Establish what are the main pathways through which maternal education affects infant mortality for each of the groups. Table 4 shows the odds ratios for infant mortality for of the different groups being considered. When it comes to the magnitude of the maternal education gradient, Table 4 displays that this varies significantly across the different groups. In the case of NHW-US, infants born to mothers with low levels of education have 262% (less than high school), 183% (high school), and 132% (some college) higher odds of dying than infants born to mothers with >=16 years of education (Model 1 no controls). A similar pattern is observed for infants born to PR-US, PR-FB, and OH-US. Infants born to NHB-US and MEX-US mothers with low levels of education have 16-53% and 25-66% higher odds respectively relative to their counterparts. In the case of MEX-FB and OH-FB, even though infants of lower educated mothers face a higher risk of dying compared to those of educated mothers, the odds are 10-23% higher for the former group and 10-34% higher for the latter, both of which are substantially lower than the higher odds observed for infants of PR-US, PR-FB, and OH-US mothers. As can be seen, the relative disadvantage decreases with increasing educational attainment levels for all groups highlighting the beneficial impact of education on infant health. That is, infants born to mothers with some college education have lower odds of dying than infants born to mothers with less than high school or just a high school degree.

The progressive inclusion of demographic, birth order, maternal health, and maternal behavior controls shows a significant reduction of the maternal education gradient in infant mortality. This result is consistent for all the racial/ethnic groups regardless of nativity status. Table 4 shows that, despite a

considerable attenuation of the maternal education gradient in infant mortality for NHW-US, MEX-US, PR-US, and OH-US infants, statistically significant differences by SES remain for these racial/ethnic groups. The maternal education is steeper for the NHW-US, MEX-US, PR-US, OH-US groups, where infants born to mothers with less than a high school education have 40%, 31%, and 46% higher odds of dying compared to the reference group (Model 6). For NHW-US, infants born to mothers with a high school degree are not disadvantaged relative to infants of educated mothers, but infants of mothers with some college education have 3.6% higher odds of dying. On the contrary, Table 4 shows that when it comes to the US-born Hispanic population, infants born to mothers with less than high school or just a high school degree have almost identical maternal education gradients. For these groups, a reduction in the mortality ORs relative to college educated women occurs only for mothers who achieve some college education. Regardless, infants born to mothers with some college education in these racial/ethnic groups still face 23-28% higher risks of dying than infants born to mothers with a college or higher educational attainment. When looking at the foreign-born Hispanic population (Mexicans, Puerto Ricans, and Other Hispanics), Table 4 shows that after the inclusion of all the controls, there is no significant difference in infant mortality among the different maternal education levels. Similar results are observed for infants born to NHB-US. More specifically, even though infants born to mothers with a high school degree have 11.6% higher odds of dying, there is no difference in infant mortality risk between infants born to mothers with less than a high school degree or some college and their college educated counterparts.

Finally, Table 4 provides insight into the main pathways through which maternal education affects infant health and how these vary across racial/ethnic boundaries. Maternal behaviors (smoking, alcohol use, weight gain, PNC) explain the largest part of the maternal education differences in infant mortality and this is persistent for all groups. The maternal education gradients for foreign-born Mexicans and Other Hispanics are the only ones that are not significantly narrowed after controlling for these measures.

After maternal behaviors, maternal health seems to be the second most important pathway through which education affects infant mortality. With the exception of MEX-US and OH-FB, maternal health accounts for a portion of the gradient. Nonetheless, this effect is more pronounced among the most disadvantaged group (i.e. infants born to mothers with less than high school) than among infants born to mothers with a high school degree or some college education. For the latter categories, a modest reduction in the gradient is observed when controlling for these factors. When looking at demographic factors, NHW-US infants are an exception in terms of how these elements influence infant health. Contrary to all the other groups, controlling for maternal age at birth and marital status had a substantial impact on the maternal education gradient of infants born to NHW-US mothers.

Table 4 portrayed the existent variability in the maternal education gradient of infant mortality. It also showed how controlling for demographic, health, and behavioral factors eliminated the gap for some racial/groups, whereas for others, even though it was reduced, the gap persisted. Furthermore, it showed that the pathways through which maternal education affects infant mortality vary across groups. Nonetheless, maternal behaviors proved to be an important pathway for all groups.

[Insert Table 4 here]

Discussion

In this study, I analyzed socioeconomic disparities in infant mortality using maternal education as the proxy for SES. Infant mortality rates progressively decrease as maternal education increases. The index of inequality showed that the magnitude of educational disparities varies across racial/ethnic groups and by nativity status. Educational disparities in overall infant mortality are larger for NHW-US, PR-US, PR-FB, MEX-US, OH-US and narrower for NHB-US and foreign-born Mexicans and Other Hispanics. When

looking at excess mortality rates, overall infant mortality would have decreased by 25-35% for infants born to NHW-US, NHB-US, Puerto Ricans (US and FB), MEX-US, and OH-US if the mortality rate for all the educational groups were the same as the rate for infants born to mothers with a college degree. On the contrary, the decline in mortality rates would have been of only 13% and 16% for foreign-born Mexicans and Other Hispanics respectively.

When looking at the maternal education gradient, it can be seen that infants born to mothers with lower levels of education have statistically significant mortality odds. The magnitude varies across racial/ethnic groups. For instance, even after controlling for demographic, health, and behavioral factors, infants born to NHW-US, Puerto Ricans (US and FB), Mexican, and other Hispanics (US-born) mothers with low levels of education face higher risks of dying compared to infants born to mothers with college or higher educational attainment. The gradient is steepest for US-NHW and PR-US; however, higher levels of education are accompanied by successive reduction in the mortality odds. It is worth mentioning that there seems to be no benefit to having a high school degree for these groups. That is, infants born to mothers with a high school degree and infants born to mothers with less than a high school degree experience higher mortality odds of the same magnitude when compared to infants born to highly educated mothers. On the contrary, having some college education results in a reduction in the mortality odds. In the case of foreign-born Mexicans and other Hispanics, there is no significant difference in infant mortality by maternal education. That is, having less than a high school degree or just a high school degree is not prejudicial for infant health. Other factors such as composition of the population, health selectivity of the mothers, healthier behaviors of the mothers, social ties, and/or culture should be considered as elements that can lead women in these groups to have positive birth outcomes despite having low educational attainment.

Finally, the main mechanism through which maternal education affects infant mortality is through maternal health behaviors. Maternal health is also an important pathway and demographic factors such as maternal age at birth and marital status matter for NHW-US. Overall, maternal education is protective of infant mortality even after controlling for multiple risk factors. Even though the magnitude of the gradient varies across groups, the benefit of higher levels of education is persistent across groups and leads to lower infant mortality rates.

Table 1. Rate ratios relative to college or higher educational attainment by race, ethnicity, and nativity: All births,2000-2008 linked files

Maternal Education	NHW-US	NHB-US	MEX-US	MEX-FB	PR-US	PR-FB	OH-US	OH-FB
Less than high school	2.6	1.5	1.6	1.2	2.4	2.0	2.0	1.3
High school degree	1.8	1.3	1.5	1.2	1.9	1.5	1.7	1.3
Some college	1.3	1.2	1.2	1.1	1.5	1.3	1.4	1.1

Note: 2006 births are not included in the analysis due to lack of data on requested variables

Table 2. Infant mortality rates per 1000 live births by maternal education, race, ethnicity, and nativity, excess mortality, and index of disparity: All births,2000-2008 linked files

	All Births					NHW-US					NHB-US				
Maternal Education (Years	Live Births	%	Infant Deaths	%	Infant Mortality	Live Births	%	Infant Deaths	%	Infant Mortality	Live Births	%	Infant Deaths	%	Infant Mortalit
<12	3,691,162	14.2	27,168	18.8	7.36	1,029,408	6.3	8,647	11.5	8.40	433,467	1.7	5,938	4.1	13.7
12	8,701,796	33.6	58,272	40.3	6.70	4,888,577	30.1	28,671	38.2	5.86	1,574,651	6.1	18,959	13.1	12.0
13-15	6,541,845	25.2	33,924	23.5	5.19	4,421,468	27.2	18,691	24.9	4.23	1,027,088	4.0	10,728	7.4	10.4
>=16	6,975,801	26.9	25,197	17.4	3.61	5,889,796	36.3	18,958	25.3	3.22	463,442	1.8	4,177	2.9	9.0
All levels	25,910,604		144,561		5.58	16,229,249		74,967		4.62	3,498,648		39,802		11.4
Excess mortality					**35.26**					**30.32**					**20.8**
Index of disparity					**58.18**					**68.63**					**25.4**
	MEX-US					**MEX-FB**					**PR-US**				
Maternal Education (Years	Live Births	%	Infant Deaths	%	Infant Mortality	Live Births	%	Infant Deaths	%	Infant Mortality	Live Births	%	Infant Deaths	%	Infant Mortalit
<12	285077	18.3	1608	21.6	5.6	1,187,290	4.6	4,762	3.3	4.01	46,095	0.2	396	0.3	8.59
12	707146	45.3	3581	48.0	5.1	770,762	3.0	3,008	2.1	3.90	113,497	0.4	795	0.5	7.00
13-15	399791	25.6	1698	22.8	4.2	238,879	0.9	863	0.6	3.61	82,117	0.3	451	0.3	5.49
>=16	167330	10.7	570	7.6	3.4	134,600	0.5	441	0.3	3.28	34,243	0.1	125	0.1	3.65
All levels	1559344		7457		4.8	2,331,531		9,074		3.89	275,952		1,767		6.40
Excess mortality					**28.8**					**15.8**					**42.99**
Index of disparity					**34.7**					**12.9**					**69.42**
	PR-FB					**OH-US**					**OH-FB**				
Maternal Education (Years	Live Births	%	Infant Deaths	%	Infant Mortality	Live Births	%	Infant Deaths	%	Infant Mortality	Live Births	%	Infant Deaths	%	Infant Mortalit
<12	26,323	0.1	232	0.2	8.81	67,526	0.3	410	0.3	6.07	242,586	0.9	1,038	0.7	4.28
12	47,773	0.2	315	0.2	6.59	181,191	0.7	915	0.6	5.05	345,836	1.3	1,368	0.9	3.96
13-15	34,743	0.1	197	0.1	5.67	147,849	0.6	614	0.4	4.15	188,006	0.7	666	0.5	3.54
>=16	23,440	0.1	106	0.1	4.52	94,178	0.4	279	0.2	2.96	168,584	0.7	541	0.4	3.21
All levels	132,279		850		6.43	490,744		2,218		4.52	945,012		3,613		3.82
Excess mortality					**29.62**					**34.45**					**16.06**
Index of disparity					**41.52**					**53.90**					**16.75**