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Grandparents' Education and Infant Health: Pathways across Generations

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Abstract

Using data from the Fragile Families and Child Wellbeing survey linked to respondents' medical records (N=2,870), this study examines the association between grandparents' education and birth outcomes and explores potential pathways underlying this relationship. Results show that having a grandfather with less than a high school education was associated with a 93 gram reduction in birthweight, a 59% increase in the odds of low birthweight, and a 136% increase in the odds of a neonatal health condition, compared to having a grandfather with a high school education or more. These associations were partially accounted for by mother's educational attainment and marital status, as well as by prenatal history of depression, hypertension, and prenatal health behaviors, depending on the specific outcome. The findings from this study call for heightened attention to the multigenerational influences of educational attainment for infant health.

Keywords

Education; Grandparents; Health; Infants; Multigenerational

Social disparities in infant health are pervasive in the United States. Rates of low birth weight, preterm births, and other infant health conditions are consistently higher among mothers with lower levels of educational attainment compared to their more advantaged counterparts (Reichman 2013). Despite years of calls to improve perinatal health outcomes, disparities by socioeconomic status (SES) have remained relatively constant over time (Healthy People 2010) suggesting that researchers lack a full understanding of the processes producing these disparities. Multigenerational influences represent one area that may help fill this gap in knowledge. Indeed, the multigenerational origins of infant health may be particularly important because poor infant health impedes SES attainment and represents a potential pathway by which inequality is transferred across generations (Palloni; 2006; Goosby & Cheadle 2009).

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Robert Mare (2011), in his Population Association of America's Presidential Address, sagaciously argued that scholars have been unjustified in ignoring the multigenerational transmission of inequality and advocated that demographers direct their research efforts toward this end. His call has resulted in an upsurge of research focused on the influences of grandparents (e.g. Sharkey & Elwert 2011; Fomby, James-Hawkins, & Mollborn 2015; Zeng & Xie 2014) but has been limited to stratification-related outcomes. Our study extends Mare's argument to infant health. The bulk of research on infant health has focused on immediate risk factors to the neglect of long-term multigenerational processes. Given that infant health is socially patterned (Blumensine et al. 2010) and SES has intergenerational origins (Warren & Hauser 1997), infant health may be at least partially rooted in multigenerational origins.

In this study, we investigate the relationship between maternal grandparent's education and birth outcomes and explore the relative plausibility of intervening social, behavioral, and biological pathways. Past research has been handicapped by data limitations as vital statistics data lacks demographic data on grandparents and most survey research lacks detailed information on birth outcomes and obstetrical data. Here we are able to surmount this issue by employing data from the Fragile Families Project which links survey data to medical files from the birth hospitalization.

BACKGROUND

Whether and to what extent grandparents' educational attainment is related to the birth outcomes of their grandchildren is unknown. Two strands of literature provide clues about this topic. First, while not focused on infant health outcomes per se, a modest but growing literature suggests that grandparents' SES status can influence the wellbeing of their grandchildren (Cherlin & Furstenberg 1992; Warren & Hauser 1997; Sharkey & Elwert 2011; Fomby et al. 2015). Overall, this literature hints that grandparents' SES can influence grandchildren's outcomes either indirectly through the status attainment of parents or indirectly through other mechanisms such as role modeling.

Second, although the small body of literature that directly examines the relationship between grandparent's SES and infant health cannot provide many definitive answers due to varying samples, study designs, and measures of SES, three tentative conclusions can be reached. Mothers from disadvantaged backgrounds in childhood tend to have children with lower birthweight compared to their more advantaged counterparts (Gavin, Hill, Hawkins, & Maas 2011; Gavin, Thompson, Rue, & Gou 2012; Kane 2015; Astone, Misra, & Leach 2007). Mother's adult SES and marital status operate as pathways connecting early life experiences to birth outcomes (Kane 2015; Gavin et al. 2011; Gavin et al. 2012). Finally, substance use appears to be a key pathway connecting mothers' early-life experiences with birth outcomes (Gavin et al. 2011; Gavin et al. 2012).

Cumulative Inequality and Under the Skin Processes

The underlying theme behind this research is that a mother is, at least partially, a product of her parent's social environment, and the consequences of this environment can reverberate across generations. We utilize Ferraro and Shippee's (2009) cumulative inequality (CI) theory to better understand how these processes may be operating in the case of birth outcomes. CI theory combines concepts from the cumulative adversity/disadvantage (CAD) literature and life course sociology to argue that conditions established in the past have an enduring impact and cumulate rather than equilibrate over time (O'Rand 2003; Mare 2011). CI theory builds upon CAD theory, posited by Dannefer (1987) and O'Rand (2003), by explicitly integrating the intergenerational transmission of inequalities into life course health processes.

Three elements of CI theory are important for this study. First, CI theory states that childhood conditions and therefore family lineage are particularly important for the accumulation of inequality. Moreover, childhood conditions are thought to be especially detrimental when disadvantage emerges early in life and persists across childhood as is often the case for mothers with low childhood SES. This proposition suggests that the health of a mother's infant at birth should be, at least partially, anchored in the conditions in which the mother was reared. Second, social inequalities emerge over the life course through developmental and demographic processes. For instance, early disadvantage could lead to lower SES attainment because it impedes the development of socioemotional resources, such as self-esteem and conscientiousness (Wickrama, O'Neil, Lee, & Wickrama 2015) or because it leads to an unmarried birth (Barber 2001). Third, inequality develops across multiple axes of inequality. Early SES disadvantage, in particular, is thought to proliferate into other domains of life (e.g. social relationships, health, coping resources) leading to a cascading influence over the life course. For example, children that experience socioeconomic adversity develop lower levels of self-esteem and personality characteristics associated with elevated cardio-metabolic risk in young adulthood (Wickrama et al. 2015).

CI theory also provides plausible links connecting these social processes and physiological functioning. CI theory emphasizes the long-term process of the accumulation of risks and stress exposure. When people sense stress, their bodies' respond with a cascade of physiological activity, including the release of adrenal hormones and autonomic nervous system activity (Shonkoff, Boyce, & McEwen 2009). While, occasional arousal of these responses is normal, chronic activation can have adverse health consequences. Over-activation of the stress response system can also result in self-regulatory efforts (e.g. smoking, alcohol misuse, poor diet, illicit drug use) to alleviate the short term physiological and psychological consequences of stress (Mezuk et al. 2013). The key point here is that chronic activation of the bodies' stress system may occur in tandem with the life course processes discussed above. This process is relevant to infant health because the health of the mother and her health behaviors during pregnancy are known to have profound effects upon infant health. Early disadvantage could also translate into adverse infant health status by way of chronic inflammation due to early infectious disease burden (Rogers & Velten 2011; Blackwell, Hayward, & Crimmins 2001). The key point is that feasible pathways exist connecting the accumulation of social disadvantage to early health outcomes.

We focus on grandparents' education because it is a good proxy for early social disadvantage of the mother and because accrued benefits from education are more permanent than other forms of SES, suggesting that education is a likely candidate in propagating multigenerational continuity in SES (Mare 2011). For instance, education confers human and social capital as well as occupational entitlements that are relatively durable and lasting over decades (Mare 2011). Moreover, educational attainment is known to be the primary driver of status attainment in the United States for cohorts born after World War II (Fischer & Hout 2006). Overall, the research suggests that grandparents' education can influence infant health through the mother's SES attainment or through social, psychological, or physiological pathways that operate independently of SES.

Grandparents' Education and Infant Health

Consistent with Mare's (2011) call to pay particular attention to the ways in which grandparents influence their grandchildren, we posit that grandparents' education can impact infant health both directly and indirectly through mother's adult environment. In particular we make two arguments. First, we argue that grandparents' education will influence mother's SES and relationship status in adulthood, which will in turn shape health exposures both prior to and after conception. Second, grandparents' education will also exert an influence on infant health above and beyond its influence on mother's adult SES and relationship status. This perspective suggests that growing up in a less-educated household creates a form of social, emotional, or biological deficit in the mother that impacts her offspring during pregnancy, above and beyond how it affects her own SES (Ben-Shlomo & Kuh 2002). Overall, grandparent's education can influence infant health through the mother's SES, health conditions, health behaviors during pregnancy, and pregnancy-related complications as shown in Figure 1.

The central idea behind this conceptual model is that grandparents' educational attainment provides the scaffolding for the mother's childhood environment. Individuals with lower levels of education are known to experience less economic success, occupational prestige, family stability, social capital and psychosocial resources and face more chronic stressors and negative life events than their more educated counterparts (Mirowsky & Ross 2003). Moreover, parents' low levels of educational attainment have known repercussions for their children. Parents with lower levels of education tend to exhibit less warmth and cognitive stimulation and more strictness, control, and rejecting behaviors, than their more educated counterparts (Wickrama, Conger, Lorenz, & Elder 1998). These parenting behaviors, in turn, are linked with a host of deleterious social, emotional, and health outcomes in adulthood (Repetti et al. 2002). Consistent with CI theory, initial advantages or disadvantages resulting from education accumulate over time and proliferate across life domains as seen in pathways "a", "e", "f", and g" in Figure 1.

Mother's Socioeconomic and Relationship Status

Lower levels of grandparents' education hinder mothers' SES attainment as well as increasing her chances of being an unwed mother, as seen in pathway "a". The key idea here is that growing up with parents with low levels of educational attainment will jeopardize the successful transition to parenthood, including mother's own educational attainment, income, and marital status during parenthood (Hauser & Featherman 1977). This relationship may operate through parenting practices, as parents with lower levels of education demonstrate more rejecting behaviors than their more highly educated counterparts, which contribute to children's social and academic failures (Wickrama et al. 1998). Exposure to negative parenting practices during childhood may also explain why women raised in low-SES families are disproportionately likely to become unwed mothers (Barber 2001). The mother's adult SES can influence chronic health conditions (pathway "b"), health behaviors (pathway "c"), and pregnancy related complications (pathway "d"), which in turn can influence infant health (Mirowsky & Ross 2003; Finch 2003).

Health Conditions and Pregnancy-Related Complications

Lower parental education may not only affect children's SES in adulthood, it may also have long-lasting influences on aspects of social, emotional wellbeing and physiological functioning (pathways e-g), through various channels—most importantly, perhaps, the home environment. Parents with low levels of education are more likely to have homes characterized by conflict, anxiety, emotional distress, fear, and anger (Repetti et al. 2002). Children exposed to such atmospheres are more likely to develop high levels of emotional reactivity, have limited emotion-based coping skills, and have difficulty understanding their own and other's emotions (Repetti et al. 2002). Moreover, such deleterious environments can have lasting effects on later health and well-being through hypothalamus-pituitary-adrenal axis dysregulation and chronic inflammation (Ferraro & Shippee 2009). For instance, adults with low levels of education have been found to have children with higher levels of stress responsivity (Lupien et al. 2000). Continual exposure to stress hormones in early life is thought to have a lasting impact on stress-related brain circuitry, which is believed to have lasting effects on emotional states, as well as bodily processes that contribute to heart disease, hypertension, and diabetes in adulthood (Shonkoff et al. 2009).

Low levels of parental education are associated with various dimensions of health in adulthood, including heart disease, hypertension, self-reported health, and depression (Hamil-Luker & O'Rand 2007; Wickrama, Conger, & Abraham 2005). Parental education is also inversely related to early exposure to chronic infections (Dowd, Zajacova, & Aiello 2009), which can predispose individuals to chronic disease in adulthood by altering their inflammatory responses (Blackwell et al. 2001). Overall, this argument is based on the notion that one's early environment influences their physiology, and over time these changes in physiology lead to chronic conditions. For this reason, mothers whose own parents have low levels of education should be at increased risk for pregnancy-related complications.

Health Behaviors during Pregnancy

Consistent with CI theory, we hypothesize that early disadvantage can influence future behavior including health-related behavior during pregnancy (pathway f). Grandparents' education may have a direct influence on mothers' health behaviors during pregnancy for three reasons. First, preferences regarding lifestyle behaviors, such as smoking, drinking, diet, and physical activity, may develop via the intergenerational transfer of attitudes, beliefs, and behaviors (Singh-Manoux & Marmot 2005; Vuolo & Staff 2013). Wickrama and colleagues (1999), for instance, provide evidence that parents with lower levels of educational attainment are more likely to engage in risky lifestyles, including smoking and heavy alcohol use, which are then transferred to their children. They argue that children learn not only specific behaviors but also a general lifestyle behavioral orientation reflected in an enduring cognitive orientation that is not easily uprooted.

Second, children exposed to early disadvantage are differentially exposed to traumatic experiences and exhibit unhealthy behaviors in adulthood as a result of these experiences (Anda et al. 1999). Third, children exposed to early disadvantage may experience more distress and physiological stress than their less disadvantaged counterparts leading them to engage in health behaviors that provide immediate relief of these symptoms such as alcohol misuse and smoking (Mezuk et al. 2012). Indeed, low levels of parental education have been empirically linked to risky health behaviors among pregnant women (Chung et al. 2010).

HYPOTHESES

Based on the above theoretical arguments, we formulate three study hypotheses. Although the first hypothesis predicts an overall association between grandparents' education and infant health, whereas the second and third test for evidence of plausible pathways, our intent is not to adjudicate between these pathways but rather to provide an exploratory analysis assessing the feasibility of each. In short, the pathways linking health conditions, health behaviors, and pregnancy-related complications to infant health will not be investigated, as much is already known about these linkages (e.g. Finch 2003).

H1:Children whose grandparents have lower levels of education will be more likely than children of more educated grandparents to: 1) weigh less than their peers at birth, 2) have an increased risk of being low birth weight, and 3) have an increased risk of having a health condition at birth.

H2:The relationships between grandparents' education and infant health will be partially explained by the mother's SES and marital status in adulthood.

H3:Holding constant mother's SES and marital status, the relationship between grandparents' education and infant health will be partially explained by mother's pre-pregnancy risk factors, health behaviors during pregnancy, and pregnancy-related complications.

DATA AND METHODS

The Fragile Families and Child Wellbeing (FFCWB) study is an ongoing longitudinal birth cohort study. Between the spring of 1998 and the fall of 2000, parents were interviewed in 75 hospitals in 20 U.S. cities shortly after their children were born. Cities were selected from all 77 cities in the U.S. with over 200,000 people, using a stratified random sample. In 18 of the cities, all hospitals within the city boundaries that had maternity wards were included. In the other two (the largest) cities, hospitals were randomly sampled. Within each hospital, births were randomly sampled from birth logs. Non-marital births were oversampled (Reichman, Teitler, Garfinkel, & McLanahan 2001). While still in the hospital after giving birth, mothers were approached by a professional survey interviewer and screened for eligibility. Mothers were eligible for the study if they and the infant's father were at least 18-years-old, if they were able to complete the interview in either English or Spanish, if the father of the newborn was living, and if they were not planning to place the child for adoption. Eligible mothers were asked to participate in a national survey about the conditions and capabilities of new parents, their relationships, and their children's well-being. A total of 4,898 mothers were interviewed after they gave birth.

As part of a supplemental study to the core survey, additional information was collected from medical records of the mother and newborn (from the birth hospitalization) for 3,684 cases. Data were abstracted from the medical records using a detailed standardized instrument (http://www.fragilefamilies.princeton.edu/medrecs.asp). The availability of medical record data depended on administrative processes of the hospitals rather than decisions of the mothers about whether to make their medical records available.

Because the benefits associated with educational attainment may be different for mothers who obtained their education in foreign countries and because educational categories are not comparable across countries, the relationship between education and birth outcomes might differ as well (Acevedo-Garcia, Soobader, & Berkman 2005). For this reason we restricted our analysis to cases where the mother and both of her biological parents were born in the US. All of the analyses reported here, however, were replicated for the full sample including foreign born mothers and grandparents and produced the same pattern of results. The final sample was selected by starting with the original 4,898 births and then sequentially dropping 1,214 cases that lacked a medical record, 618 cases with foreign born mothers, 146 cases with one or two foreign-born maternal grandparents, and 28 cases with missing data on birth outcome

Missing data from item non-response was handled through multiple imputation using STATA's mi impute command to give a final sample size of 2,870. All variables used in the analysis other than the dependent variables were incorporated in the imputation to create five data sets. This technique provided pooled regression coefficient estimates derived from the estimates for each of the five imputed data sets. Other methods for addressing missing data, e.g. listwise deletion, were also employed in ancillary analyses and produced the same substantive findings as those reported here.

Infant Health

Three main indicators of infant health are a continuous measure of birthweight in grams, a dichotomous indicator of low birthweight, and a dichotomous measure of any abnormal infant health condition. All of the information needed to create these measures came from the infants' medical records. Infants with birthweight below 2,500 grams were coded as low birthweight (LBW). Abnormal health conditions were coded by an outside pediatric consultant, who systematically reviewed the medical record data on infant conditions, as well as data from the 1-year interviews on physical disabilities of the child (identifying serious conditions that were likely present at birth), and coded all conditions based on the degree of severity and the likelihood that they were caused by maternal prenatal behavior (the coding grid and explanation are available in Reichman, Corman, & Noonan 2009). If the infant had a condition that the consulting pediatrician classified as likely or possibly related to maternal behavior (which could be the result of the mother's early life conditions), the child was assigned a one; otherwise they received a zero. If the connection to maternal behavior was unknown, the child was coded as one, although we assessed sensitivity to this coding decision.

Grandparent's Education

Grandparent's education was assessed by the following question posed to the mother one year after giving birth and pertaining to each of her biological parents: "What is the highest grade of school that your biological mother/father completed?" Answers ranged from none to graduate or professional degree. Each grandparent's education was collapsed into two dichotomous categories: less than high school, and high school or higher. More detailed education categorizations were utilized in supplementary analyses, but because the results largely reflected a difference between those with less than high school and those with a high school degree or higher, we decided to categorize education in this parsimonious manner. Mothers who did not participate in the 1-year interview were asked identical questions about their parents' education at years three, five, and nine. If grandparent's education was not available at year one, it was obtained from the next available interview.

Mother's Socioeconomic Status

The mother's level of education is characterized by whether she had less than a high school education, a high school education, or more than a high school education. Another indicator was constructed to identify whether the mother was married to the biological father at birth. Finally, whether Medicaid paid for the birth was used as a proxy for poverty in adulthood.

Health Conditions, Health Behaviors during Pregnancy, and Pregnancy-related Complications

Pre-pregnancy factors from the medical file included history of depression, history of substance abuse, pre-pregnancy abuse, history of abortion, pre-pregnancy diabetes, and pre-pregnancy hypertension. We included dichotomous indicators for each of these conditions, as well as for abuse during pregnancy, first trimester care, any prenatal smoking, any prenatal alcohol consumption, and any illicit drug use during pregnancy. We used the medical record information on the timing of prenatal care initiation (when a date was available) to construct a measure of whether the mother received first trimester care. For the mothers with missing information, we used self-reports of the trimester that care was acquired from the mother's baseline survey. Mothers were coded as having used substances on the basis of evidence in the medical records or positive post-partum self-reports; combining the two is a strategy that others have found to be the best way to ascertain prenatal substance use (Arendt, Singer, Minnes, & Salvator 1999; also see Reichman et al. 2009, which used data from the Fragile Families Project: Medical-Link File).

Finally, the presence of pregnancy-related complications—in particular, pre-eclampsia, gestational diabetes, and gestational hypertension—were identified from the medical records and coded. These conditions were chosen because they are thought to influence fetal development and their prevalence varies by maternal education (Silva et al. 2008).

Demographic Background and Other Controls

Race and ethnicity were based on mothers' self-reports. They were coded dichotomously with categories for non-Hispanic white, non-Hispanic black, Hispanic, and other. Maternal age (<20 years and 35+ years, versus 20–34 years) was also based on mothers' reports. A control for whether the mother lived with both of her biological parents at age fifteen, also based on self-reports, was also included. Models also controlled for the infant's sex.

Analytical Strategy

We estimated a series of six nested logistic or ordinary least squares regressions for each of the three infant health outcomes to test the study hypotheses. First, we examined the relationship between the grandparents' education and infant health, net of a limited set of demographic background variables (model 1). Second, we tested the hypothesis that grandparent's education operates through the mother's status attainment by adding mother's educational attainment, marital status, and Medicaid birth to model 1 (model 2). To the extent that grandparent's education influences infant health because it is related to the mother's SES and marital status, the associations between grandparent's education and infant health should decrease between models 1 and 2. If an association between grandparent's education and infant health persists after accounting for the mother's SES and marital status, this finding would suggest that grandparents' education impact infant health independent of the mother's SES. The third through fifth models examines how these processes may be operating to influence infant health. If the association between grandparents' education and infant health found in model 2 decreases with the inclusion of pre-pregnancy health conditions (model 3), prenatal health behaviors (model 4), or pregnancy-related complications (model 5), this finding would suggest that grandparents' education could be operating via these pathways. All of these potential pathways are included together in the sixth and final model.

We conducted a number of ancillary analyses that, alternatively, explored differential effects by race/ethnicity, included only mothers who knew their fathers growing up, and included only grandmother's (or alternatively) only grandfather's education. Given that the influence of education is sometimes found to differ by race, it seems plausible that grandparent's education has differential effects as well (Kimbro, Bzostek, Goldman, & Rodriquez 2008). It is also possible that the influence of grandfather's education only matters to the extent to which the mother knew her father during her formative years. Many of the potential pathways that a grandfather's education impacts infant health presuppose that the mother interacted with her father; the learning of a healthy lifestyle, for instance, is contingent on learned behaviors acquired from one's parents. Finally, to the extent that grandmother's and grandfather's education are correlated, the estimated effects of one grandparent's education may be picking up effects of the other grandparent's education. The results from this set of ancillary analyses paralleled all of the substantive findings from our main analyses. That is, estimated effects of grandparents' education did not differ substantially by race/ethnicity and were not substantively affected by the inclusion of mothers who did not know their fathers growing up, and the estimated effects of each grandparent's education were robust to the exclusion of the other's from the model.

We also replicated our analyses using alternative birthweight-related measures. All low birthweight infants are preterm, growth retarded, or both. Because the biological processes that produce low birthweight may differ by whether the infant was preterm or small for gestational age, the relationships of interest may also vary by these birthweight-related outcomes. We thus estimated models with preterm birth, defined as delivery before 37 complete weeks of gestation, and small for gestational age, defined as less than 10th percentile of birth weight for week of gestational age, as outcomes. The results using each of these alternative outcomes are similar to those for low birthweight, indicating that the specific etiologies of low birthweight are not important for our analysis.

RESULTS

The mean values for all analysis variables stratified by grandparent's education are presented in Table 1. Infants whose grandmothers had less than a high school education did not differ significantly with respect to birthweight, low birthweight, or having an abnormal health condition compared to their counterparts whose grandmothers had a high school education or more. Those whose grandmothers had less than a high school education were less likely to be black, more likely to be Hispanic, more likely to have had a mother with less than a high school education, and more likely to have had Medicaid-financed births than those whose grandmothers had a high school education or more.

Compared to infants whose grandfathers had at least a high school education, those with less educated grandfathers did not differ significantly in terms of birthweight or low birthweight but had a higher chance of being born with a health condition. Children with less educated grandfathers were also less likely to be black, more likely to be Hispanic, less likely to have come from intact families, more likely to have mothers with less than a high school education, more likely to have had Medicaid-financed births, more likely to have mothers with history of depression, and more likely to have mothers who experienced abuse prior to pregnancy. Those with more educated grandfathers were less likely to have mothers who smoked during pregnancy.

While no statistically significant differences were found for birthweight or low birthweight between infants whose grandfathers had less than a high school education and those whose grandfathers were more highly educated, relationships were found in the multivariate models (see Tables 2 and 3) that adjust for race. This "suppressor effect" was driven by the fact that our data contain a large proportion of Hispanics who have low levels of education but relatively good birth outcomes, and blacks, who have higher levels of education than Hispanics but lower birthweight. Also, blacks at all levels of grandfather education generally had lower average birthweights than whites and Hispanics with low educated grandfathers (not shown). Overall, once we controlled for race/ethnicity, the associations between education and birthweight outcomes looks more like what we would expect.

Model 1 in Table 2 showed that infants with less educated grandfathers were about 93 grams lighter at birth than those with more educated grandfathers. In contrast, grandmother's education was unrelated to birthweight. Model 2 incorporated mother's SES (education, marital status, and Medicaid birth) and showed that mothers with any college as well as mothers with marital births delivered heavier infants. The magnitude of these coefficients was similar to that of grandfather's education; for instance, having a mother with less than a high school education was associated with 96 grams lower birthweight. The inclusion of mother's SES produced a small decrease in the relationship between grandfather's education and birthweight, from 93 to 85 grams, and the coefficient was no longer statistically significant at conventional levels (p = .07). This slight drop in the association between grandfather's education and birthweight suggested that infants with less educated grandfathers had an increased risk of low birthweight partly because their mothers had lower education and were not married.

In Model 2, which incorporated pre-pregnancy conditions, including psychosocial and biological risk factors, the coefficient for less educated grandfathers further dropped to -75 grams. This reduction suggested that infants with less educated grandfathers had mothers with higher levels of pre-pregnancy risk factors. Mothers with a history of depression had infants that weighed 135 grams less, on average, than those who did not have depression, and those with a history of hypertension had infants who weighed 160 grams less than those who did not have a history of hypertension, all else equal. Model 4 showed that prenatal care in the first trimester was not associated with birthweight, while prenatal smoking, alcohol, and drug use were all associated with lower birthweight. The coefficient associated with grandfather's education dropped from -75 in model 3 to -59 grams in model 4, suggesting that childbearing women with less educated fathers were more likely to have a history of depression or hypertension and to smoke cigarettes, drink alcohol, and use illicit drugs during pregnancy compared to those with more educated fathers.

Model 5 incorporated pregnancy-related complications and showed that while these factors were strongly predictive of birthweight, they did not explain any of the grandfather education effect, which actually became statistically significant (i.e., the p-value declined from .07 in model 2 to .04 in model 5, which we suspect is due to the fact that grandfather's education was associated with gestational diabetes, which was positively associated with birthweight). These results indicated that by not taking into account gestational diabetes, the relationship between grandfather's education and birthweight may be obscured. Model 6, which incorporated all of the potential pathways, reduced the estimated effect of grandfather's education on birthweight from -85 (model 2) to -54 grams. The coefficient for the mother's history of depression also decreased substantially from model 2 and was no longer statistically significant. Supplementary analyses showed that the relationship between depression and birthweight was accounted for by health behaviors rather than pregnancy complications, suggesting that a history of depression may have prompted smoking, alcohol, or drug use, which in turn led to lower birthweight.

Table 3 shows a similar pattern for low birth weight. Model 1 showed that grandmother's education was not associated with whether the child weighed less than 2500 grams at birth. Infants with less educated grandfathers, however, had approximately 59% increased odds of being low birthweight. Mothers with higher levels of education were less likely to have low birthweight infants than their less educated counterparts. The magnitudes of the estimated effects for mother's education were similar to that for grandfather's education. The inclusion of mother's SES-related factors led to a decrease in the odds ratio for grandfather's education from 1.59 to 1.54.

Models 3 through 6 showed the same general pattern of findings for low birthweight as that found for the continuous measure of birthweight. History of depression, hypertension, smoking, and drug use partially accounted for the relationship between grandfather's education and low birthweight, controlling for the mother's SES-related factors measured birth. The odds ratio associated with grandfather's education declined from 1.54 (model 2) to 1.38 (model 6) and was no longer statistically significant. Unlike the associations found for birthweight, alcohol use was unrelated to low birthweight and did not explain any of the relationship between grandfather's education and low birthweight.

Table 4 presented corresponding models with infant health condition as the outcome and, overall, shows a similar pattern to that for birthweight and low birthweight. Model 1 showed that grandmothers' education was not associated with a health condition at birth. Infants with less educated grandfathers, however, had approximately 136% increased odds of being born with a health condition ($p < .01$). Model 2 showed that more educated mothers and married mothers were less likely to give birth to a child with a health condition than their less educated and unmarried counterparts. While the associations between both mother's education and marital status and the likelihood the infant had a health condition were quite strong, the inclusion of these variables resulted in only a modest decline in the association between grandfather's education and the presence of an infant health condition, suggesting that infants with less educated grandfathers were at moderately increased risk of having a health condition because their mothers had lower education and were more likely to be unmarried.

The inclusion of prenatal psychosocial factors and health conditions in the model reduced the association between health conditions and having a grandfather with less than a high school education from 2.2 (model 2) to 2.0 (model 3). Most notably, maternal history of depression was associated with nearly a 500% increase in the odds of an infant health condition. Model 4 showed that mothers who used illicit drugs had markedly increased odds of having an infant with a health condition; the inclusion of prenatal behaviors in the model resulted in a drop in the odds ratio for grandfather's education from 2.2 (model 2) to 1.6 (model 4). Model 5, showed that the pregnancy-related complications considered were unrelated to the presence of an infant health condition and the inclusion of this set of variables in the model did not result in a decline in the odds ratio for grandfather's education. Model 6 incorporated all pathways of interest into the model and resulted in a reduction in the odds ratio for grandfather's education from 2.2 (model 2) to 1.5.. The odds ratio for history of depression dropped from 5.6 (model 2) to 2.1 (model 6); supplementary analyses showed that the relationship between depression and the presence of a health condition was accounted for by prenatal drug use, suggesting that mothers' history of depression may have prompted drug use, which in turn increased the risk of a health condition.

Infants with grandmothers who had a high school education or more were more likely to have a health condition than those with less educated grandmothers, as seen in Models 2, 3, and 5. This finding, however, was unique to these model specifications. Grandmother's education was not statistically significant in model 1, which did not include mother's SES, or when grandmother's and grandfather's education were included in models separately. In addition, as seen in Table 1, there was no bivariate association between grandmother's education and infant health condition.

Taking all the results together, we found that infants with less educated grandfathers were less healthy at birth compared to those with more educated grandfathers, whereas grandmother's education did not appear to have an independent effect. The magnitude of the associations between grandfather's education and infant health outcomes were similar to those of the mother's own education and marital status. The influence of grandfather's education was partially accounted for by mother's adult SES, and when controlling for the mother's adult SES, by mother's history of depression and pregnancy-related health behaviors. Infants whose grandfathers had less than a high school education may have had worse health because their mothers disproportionately experienced depression, which elicited deleterious health behaviors during pregnancy. While we could not establish a temporal ordering between history of depression and health behaviors, it seems plausible that previous exposure to depression created a tendency for the mother to engage in smoking, drinking, or drug use.

CONCLUSIONS

This study took Mare's (2011) argument that researchers have been amiss in ignoring multigenerational inequality and applied it to the case of infant health. Our study suggests that Mare's warning was well-justified as it indeed shows that grandfather's education shapes infant health independent of the mother's SES and marital status. This study explored how grandparents' education is related to birth outcomes, measured by birthweight, low birthweight, and infant health conditions. We tested three specific hypotheses: (1) infants with less educated grandparents will have worse birth outcomes than their counterparts with more educated grandparents, (2) mother's current SES and marital status will partially account for this association; and (3) mother's prenatal health conditions, prenatal health behaviors, and pregnancy complications will account for another part of the association, controlling for mother's adult SES. We found evidence in support of all three hypotheses, although all grandparent education effects were limited to grandfathers.

Specifically, results showed that: (a) having a grandfather with less than a high school education was associated with lower birthweight and increased odds of both low birthweight and an infant health condition; (b) these associations were partially explained by mother's adult SES and marital status, and (c) depending on the specific outcome, the associations between grandfathers' education and child health were partially explained by mother's history of depression, history of hypertension, and prenatal health behaviors, net of mothers' adult SES. Although these findings are consistent with our hypotheses, one important question stands out: Why did grandfathers' education matter for infant health but not grandmothers' education?

We found very robust evidence that higher educational attainment among grandfathers but not grandmothers was associated with better infant health and several relevant pathways. We suspect that the differential and somewhat surprising (Sear and Mace 2008) finding for grandfathers versus grandmothers reflects, at least partially, the gender-segregated social landscape regarding education that prevailed in earlier cohorts (Percheski 2008). The births in our sample occurred between 1998 and 2000 and the average age of the mothers was 25. While we have no information on the grandparents' dates of birth, we can make an educated guess based on the ages of the mothers in our sample. With the average mother in our sample being 25 and assuming that the grandmother gave birth to the child's mother at age 25, the grandmother would have been born circa 1948. The SES of households in older cohorts is thought to reflect the father's education much more than the mother's, as men's education conferred more social and economic benefits than women's education (Hauser & Featherman 1977). Indeed, there were fewer work opportunities for women in older cohorts compared to younger cohorts. Moreover, in the past it was rare for women to obtain higher education, and women that did were less likely to marry and have children (Goldstein & Kenney 2001). We suspect that the importance of the grandmother's education for infant health has increased among younger cohorts.

At least three important points can be gleaned from this study that inform our knowledge of the multigenerational origins of infant health and provide direction for future research in this area. First, the key finding produced from this study is that education's health influence crosses generations. Recently, there has been a substantial amount of attention paid to the linkage between education and adult health and mortality (e.g., Montez 2015). An essential premise of this literature is that education confers social, economic, and emotional resources that translate into improved health and represent a fundamental cause of health (Masters, Link, & Phelan 2015). Education may represent a fundamental cause of health not only for the individual, but also for his or her offspring. Because fundamental cause theory posits that the manner in which education operates to impact health can change over time and place, the underlying mechanisms connecting education and health of subsequent generations may differ as well (Masters et al. 2015). Moreover, different levels of educational attainment may confer different health advantages as the educational composition of the U.S. population changes over time. In order to have a more complete understanding of the multigenerational effects of education, future research should examine the influence of education and its associated mechanisms across generations for different populations and cohorts. Our findings—if they can be replicated for other samples and cohorts—suggest that education confers greater benefits than are currently considered and provide further rationale for early education intervention, for investments in education more generally, and for viewing education policy as health policy.

Second, intricate multigenerational selection and causal processes are likely at play in how education impacts health more broadly. The vast literature on education and health has focused on the extent to which adult education is associated with adult health (Johnson et al. 2016). This literature often controls for health conditions (e.g. hypertension) that developed prior to educational attainment in trying to establish the causal impact of adult education on health. Here we showed that such factors may not simply be spurious factors to be controlled for, but instead may be key linkages connecting family lineages of educational attainment to infant health. Our study provides additional impetus for calls to understand the complex life course processes of selection and causation that are playing out over multiple generations to impact health (Johnson et al. 2016).

Third, mental health and health behaviors may be key pathways by which grandparent's low education impacts infant health. Because a history of depression and pregnancy-related health behaviors were found to account for a substantial share of the influence of grandfather's education net of the mother's adult SES, future work should focus more explicitly on linkages between the mother's early-life environment, her life course exposure to depression, and her health behaviors prior to and during pregnancy. A better knowledge of when exposure to depression is most harmful and how this is related to future health behaviors may be particularly important in attempting to identify why grandfathers' education is protective of the mother's offspring.

Several limitations should be noted. First, spurious relationships due to unmeasured factors may confound our findings. For example, both infant health and educational attainment may be related to genetic predispositions, and our findings thus may reflect effects of such an unobserved factor. Two genetically-informed studies, however, suggest that this scenario is unlikely (De Stavola, Leon, & Koupil 2011; Kane 2015). Second, we were not able to establish that grandfather's education was acquired during the mother's childhood. Most education, however, is obtained in young adulthood, especially among younger cohorts (Percheski 2008). Third, we were not able to account for the quality of healthcare that may vary by social status, and our sample was restricted to mothers that gave birth in hospitals. Fourth, our measure of prenatal history of depression did not provide information on the timing, severity, or duration of depression, and we suspect that these factors are important for understanding how multigenerational influences unfold over time. Fifth, we were not able to verify that the biological grandmother raised the mother. If the mother was raised by someone else, we wouldn't expect grandmother's education to be as influential for infant health. Finally, we used a relatively disadvantaged sample that was disproportionately weighted to non-marital births.

Similar to the literature on stratification, the research on health disparities in infant health has mostly focused on intergenerational patterns to the exclusion multigenerational ones (Mare 2011; Blumineshine et al. 2010). Our paper addressed this issue by considering mother's early life social environment, as measured by grandparents' education, as a predictor of the health of her own children. With recent interest in viewing education as one way of improving population health (Montez 2015), a high priority should be placed on obtaining a fuller understanding of whether, under what conditions, to what extent, and how education confers multigenerational health benefits.

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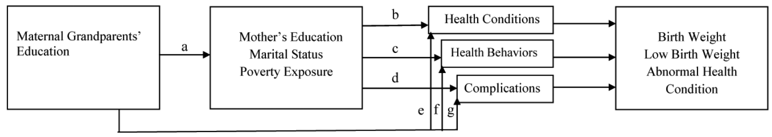

Figure 1. Educational Origins of Infant Health across Generations

Notes: Health conditions represent the presence of chronic health conditions and risk factors prior to pregnancy such as hypertension and history of depression. Health behaviors represent behaviors during pregnancy including accessing 1st trimester prenatal care, smoking, drug use, and alcohol use. Complications represent pregnancy-related complications such as gestational diabetes and preeclampsyia. Health conditions, health behaviors, and complications are staggered to reflect differential temporal ordering.

Table 1

Descriptive Statistics Stratified by Grandparent's Educational Attainment after Multiple Imputation (N=2,870)

	Grandmother Less than High School (N=371)		Grandmother High School or Higher (N=2,499)			Grandfather Less than High School (N=385)		Grandfather High School or Higher (N=2,485)		
	Mean	Standard deviation	Mean	Standard deviation		Mean	Standard deviation	Mean	Standard deviation	
Birthweight (grams)	3181	626	3179	629		3132	646	3188	626	
Low birthweight	0.13	0.33	0.12	0.32		0.15	0.36	0.12	0.32	
Infant health condition	0.05	0.21	0.05	0.22		0.08	0.27	0.05	0.21	*
Mother's age <20	0.20	0.40	0.20	0.40		0.19	0.39	0.21	0.40	
Mother's age >30	0.23	0.42	0.20	0.40		0.22	0.41	0.21	0.40	
Female	0.49	0.50	0.48	0.50		0.49	0.50	0.48	0.50	
Black	0.38	0.48	0.59	0.49	***	0.41	0.49	0.59	0.49	***
Hispanic	0.47	0.50	0.15	0.36	**	0.41	0.49	0.16	0.36	***
Other race/ethnicity	0.01	0.12	0.02	0.12		0.01	0.12	0.02	0.12	
Lived with both parents at 15	0.37	0.48	0.36	0.48		0.40	0.49	0.35	0.48	*
Mother less than high school	0.45	0.50	0.32	0.46	***	0.40	0.49	0.33	0.47	**
Mother high school	0.33	0.47	0.33	0.47		0.36	0.48	0.32	0.47	
Married to father	0.16	0.37	0.20	0.40	*	0.18	0.39	0.20	0.40	
Medicaid use	0.73	0.44	0.62	0.49	***	0.71	0.46	0.63	0.48	**
History of depression	0.10	0.30	0.12	0.32		0.14	0.34	0.11	0.32	*
Pre-pregnancy abuse	0.03	0.18	0.03	0.18		0.05	0.21	0.03	0.17	*
Abuse during pregnancy	0.03	0.16	0.03	0.16		0.01	0.12	0.03	0.17	***
Had abortion in past	0.42	0.49	0.45	0.50		0.41	0.49	0.45	0.50	
Pre-existing cardiovascular disease	0.04	0.20	0.04	0.20		0.04	0.20	0.04	0.20	
Pre-existing diabetes	0.01	0.10	0.01	0.11		0.01	0.09	0.01	0.11	
Pre-existing hypertension	0.02	0.15	0.03	0.18		0.03	0.16	0.03	0.18	
Prenatal care started 1st trimester	0.42	0.49	0.46	0.50		0.43	0.50	0.46	0.50	
Smoking during pregnancy	0.26	0.44	0.25	0.43		0.30	0.46	0.24	0.42	**
Alcohol use during pregnancy	0.09	0.29	0.08	0.27		0.10	0.31	0.08	0.27	
Drug use during pregnancy	0.11	0.31	0.12	0.33		0.15	0.36	0.12	0.32	
Preeclampsia	0.05	0.21	0.05	0.22		0.06	0.23	0.05	0.22	

	Grandmother Less than High School (N=371)		Grandmother High School or Higher (N=2,499)		Grandfather Less than High School (N=385)		Grandfather High School or Higher (N=2,485)	
	Mean	**Standard deviation**	**Mean**	**Standard deviation**	**Mean**	**Standard deviation**	**Mean**	**Standard deviation**
Gestational diabetes	0.06	0.24	0.04	0.20	0.06	0.24	0.04	0.20
Gestational hypertension	0.08	0.27	0.09	0.28	0.10	0.30	0.08	0.28

* p<.05;

** p<.01;

*** p<.001 (two-tailed).

Table 2

Ordinary Least Squares Regression Predicting Birthweight (N=2,870)

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
Grandmother less than high school (ref > high school)	15.735		31.206		21.481		18.156		22.411		4.854	
Grandfather less than high school (ref > high school)	−92.533	*	−84.562		−74.682		−58.695		−85.745	*	−54.228	
Mother's age <20 (ref 20-30)	−52.691		−19.872		−31.795		−42.723		−15.582		−44.735	
Mother's age >30	−37.947	*	−79.988	*	−58.655		−46.707	*	−88.025	**	−43.696	
Female	−89.526	***	−88.984	***	−90.087	***	−85.055	***	−86.792	***	−83.823	***
Black (ref=white)	−218.414	***	−174.447	***	−174.23	***	−193.038	***	−172.535	***	−187.76	***
Hispanic	−59.328		−20.059		−28.398		−57.557		−18.749		−57.033	
Other race/ethnicity	−33.597		−20.199		−23.666		−20.634		−26.483		−32.055	
Lived with both parents at 15	13.499		−6.263		−8.867		−15.208		0.421		−9.516	
Mother less than high school			−95.568	**	−80.901	*	−41.766		−87.875	**	−30.735	
Mother high school (ref > high school)			−89.088	**	−84.805	**	−69.989	*	−92.444	**	−72.293	*
Married to father			70.369	*	63.676		20.311		77.911	*	28.210	
Medicaid use			−35.480		−30.875		−17.400		−29.845		−13.042	
History of depression					−134.881	***					−50.475	
Pre-pregnancy abuse					−95.430						−76.395	
Abuse during pregnancy					55.867						78.659	*
Had abortion in past					−9.361						−5.360	
Pre-existing cardiovascular disease					61.914						68.507	
Pre-existing diabetes					139.393						136.225	
Pre-existing hypertension					−160.149	*					−143.577	*
Prenatal care started 1st trimester							44.744				37.491	
Smoking during pregnancy							−143.192	***			−142.001	***
Alcohol use during pregnancy							−119.554	**			−113.285	*
Drug use during pregnancy							−104.642	**			−93.653	**
Preeclampsia									−240.841	***	−225.237	***
Gestational diabetes									235.333	*	222.138	***
Gestational hypertension									−122.54	**	−138.60	**

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
Constant	3,382.37	***	3,425.54	***	3,440.97	***	3,451.82	***	3,429.04	***	3,463.73	***

***
p<0.001,

**
p<0.01,

*
p<0.05 (two-tailed).

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Table 3

Estimated Odds Ratios: Logistic Regression Predicting Low Birthweight (N=2,870)

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
Grandmother less than high school (ref > high school)	0.988		0.929		0.986		0.980		0.953		1.040	
Grandfather less than high school (ref > high school)	1.587	*	1.541	*	1.470		1.407		1.550	*	1.383	
Mother's age <20 (ref 20-30)	1.350	*	1.189		1.307		1.305		1.187		1.401	*
Mother's age >30	1.423	*	1.656	***	1.411	*	1.449	*	1.722	***	1.348	
Female	1.161		1.153		1.161		1.136		1.137		1.131	
Black (ref=white)	1.559	**	1.312		1.330		1.407	*	1.309		1.422	*
Hispanic	0.810		0.690		0.741		0.801		0.690		0.833	
Other race/ethnicity	0.447		0.418		0.420		0.431		0.403		0.423	
Lived with both parents at 15	0.988		0.936		0.959		0.955		0.892		0.933	
Mother less than high school			1.484	*	1.358		1.233	***	1.445	*	1.172	
Mother high school (ref > high school)			1.298		1.263		1.213		1.332		1.245	
Married to father			0.748		0.786		0.879		0.712	*	0.861	
Medicaid use			1.191		1.131		1.123		1.148		1.057	
History of depression					1.953	***					1.549	*
Pre-pregnancy abuse					1.706						1.656	
Abuse during pregnancy					0.841						0.763	
Had abortion in past					1.139						1.148	
Pre-existing cardiovascular disease					1.061						1.040	
Pre-existing diabetes					0.878						0.908	
Pre-existing hypertension					2.036	**					2.012	*
Prenatal care started 1st trimester							0.989				1.019	
Smoking during pregnancy							1.594	***			1.574	**
Alcohol use during pregnancy							1.243				1.168	
Drug use during pregnancy							1.540	**			1.407	
Preeclampsia									2.191	***	2.059	**
Gestational diabetes									0.397	*	0.377	*
Gestational hypertension									1.907	***	2.130	***

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
Constant	0.072	***	0.072	***	0.061	***	0.060	***	0.068	***	0.048	***

*** p<0.001,

** p<0.01,

* p<0.05 (two-tailed).

Table 4

Estimated Odds Ratios: Logistic Regression Predicting the Presence of a Health Condition at Birth (N=2,870)

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
Grandmother less than high school (ref > high school)	0.588		0.480	*	0.522	*	0.633		0.483	*	0.636	
Grandfather less than high school (ref > high school)	2.361	**	2.233	**	1.981	*	1.640		2.261	**	1.554	
Mother's age <20 (ref 20-30)	0.504	*	0.348	***	0.384	**	0.398	**	0.343	***	0.408	**
Mother's age >30	2.447	***	3.703	***	2.990	***	2.357	**	3.871	***	2.273	***
Female	1.169		1.106		1.128		1.147		1.081		1.154	
Black (ref=white)	2.394	***	1.372		1.664		1.095		1.365		1.198	
Hispanic	1.581		0.918		1.302		1.144		0.925		1.293	
Other Race	1.797		1.466		1.668		1.351		1.475		1.424	
Living with both parents at 15	0.502	***	0.600	*	0.617	*	0.560	*	0.572	**	0.531	**
Mother less than high school			4.081	***	3.229	***	2.161		3.981	***	2.164	*
Mother high school (ref > high school)			2.156	**	2.014	*	1.791	**	2.192	**	1.939	*
Married to father			0.221	***	0.239	***	0.386	*	0.209	***	0.389	*
Medicaid use			1.117		0.966		0.857		1.079		0.795	
History of depression					5.560	***					2.088	**
Pre-pregnancy abuse					1.790						1.487	
Abuse during pregnancy					0.490						0.403	
Had abortion in past					0.949						0.877	
Pre-existing cardiovascular disease					1.167						1.176	
Pre-existing diabetes					0.727						1.315	
Pre-existing hypertension					1.161						1.943	
Prenatal care started 1st trimester							0.711				0.722	
Smoking during pregnancy							1.433				1.347	
Alcohol use during pregnancy							1.223				1.147	
Drug use during pregnancy							14.525	***			13.273	***
Preeclampsia									1.955		2.336	*
Gestational diabetes									0.398		0.402	
Gestational hypertension									1.428		1.855	

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
Constant	0.026	***	0.019	***	0.013	***	0.014	***	0.019	***	0.011	***

*** p<0.001,

** p<0.01,

* p<0.05 (two-tailed).