Grandparents’ Wealth and the Body Mass Index Trajectories of Grandchildren

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Abstract

The association between childhood obesity and family socioeconomic status is well-established. However, little is known about how grandparental wealth—a measure of historical socioeconomic advantage—is associated with grandchildren’s initial body mass index (BMI) in early childhood and its subsequent growth patterns. Guided by life course perspective as well as the cumulative (dis)advantage theory, this analysis investigates the link between grandparents’ wealth ranking and grandchildren’s BMI growth trajectories from childhood to early adulthood. Analyses are based on longitudinal data from the U.S. Panel Study of Income Dynamics (PSID) and the supplemental studies of Child Development Supplement (CDS) and Transition to Adulthood (TA). Using three-level growth curve models, I track the BMI trajectories of a nationally representative sample of individuals from childhood to early adulthood. I find that lower grandparental wealth ranking is not only associated with slightly higher initial BMI of their grandchildren, it is also associated with accelerated BMI growth trajectories. Results highlight the role of wealth as a historical socioeconomic (dis)advantage in accounting for the obesity disparities between white and black children in the current generation.

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The prevalence and severity of obesity have been increasing in children and adolescents (Ogden, Carroll and Flegal 2008; Olds et al. 2011). This obesity epidemic is a serious public health concern because obesity in childhood dramatically increases the probability of obesity in adulthood (Guo et al. 2002; Singh et al. 2008), and they are established risk factors for both physical and psychological health over the life course (Carr and Friedman 2005). Research focusing on how family socioeconomic characteristics can explain childhood obesity suggests that lower socioeconomic status (SES) and the associated behavioral and environmental risk factors are important determinants of excess body weight and obesity among children (Gordon-Larsen, Adair and Popkin 2002; Sobal and Stunkard 1989). However, little is known about the association between grandparental socioeconomic status—particularly wealth accumulation—and grandchildren's body mass growth trajectories. Given there is a substantial degree of rigidity in wealth distribution across generations (Pfeffer and Killewald 2015; Piketty 2015; Wolff 2016), the wealth profile of grandparents can be particularly important in shaping the socioeconomic status of the parent generation as well as the body mass index of the grandchildren's generation.

Prior research is further limited by the insufficient attention given to growth trajectories of BMI from childhood to early adulthood (Li et al. 2008; Pryor et al. 2011). Early-life trajectory of BMI is an important indicator for childhood and future wellbeing (Nasiri-Rine and Salar-Kia 2004), and children with appropriate growth trajectory are significantly less likely to have nutritional disorders or develop chronic diseases (Stevenson et al. 2006). For instance, excessive weight gain may indicate obesity risk, which can track from childhood to adulthood (Bayer et al. 2011; Evensen et al. 2016), and cause major physical and psychosocial problems, both in the short- and long-run (Must and Strauss 1999). Adverse SES exposure and under-nutrition during the fetal life and early childhood might lead to an elevated risk for excessive catch-up growth or "early adiposity rebound" (Barker et al. 2002; Barker et al. 2005). This type of early childhood catch-up growth, in turn, is a well-established predictor of adult obesity (Rolland-Cachera et al. 2006; Taylor et al. 2005; Whitaker et al. 1998) and other chronic diseases (Eriksson et al. 1999; Huxley, Shiell and Law 2000).

In this article, I use data from the Panel Study of Income Dynamics (PSID) and its Child Development and Transition to Adulthood supplement studies to track the BMI trajectories of a nationally representative sample of individuals from childhood to early adulthood. I also examine whether and to what extent grandparental wealth matters for grandchildren's initial BMI levels and their subsequent BMI growth patterns. I pay particular attention to the racial differences of BMI trajectories and their associations to grandparental wealth between non-Hispanic white and non-Hispanic black children.

Theoretical Background and Hypotheses

The life course perspective provides a useful theoretical foundation for studies that consider the relationship between grandparents' wealth and body mass index and its change over time among grandchildren (Bengtson and Black 1973; Elder 1985; Hareven 1986). This perspective is consisted of several principles, including *life-span development, linked lives, historical time and space*, and *human agency*. The first principle of life span development is characterized by the view that individual's biological, social, and psychological developments are shaped by earlier experiences (Elder, Johnson and Crosnoe 2003). According to this view, it is necessary to take a long-term view to understand children's growth trajectories and the factors that shape them. The second principle of *linked lives* argues that individual development is embedded in integrated social, particularly kin, relationships that extend beyond nuclear family ties. These extended kinship ties may shape individual experiences and life chances (Giele and Elder 1998). The lives of parents and children are obviously linked; likewise, grandparents' and grandchildren's lives are also linked through not only blood but also through shared resources, values, and environment. The third principle of *historical time and space* points to the fact that the life course of an individual is embedded and shaped by historical (i.e. period-specific) forces. For instance, the legacy of racial inequality in wealth provides a strong context in which grandparental effect unfolds today. Finally, the *human agency* principle assumes that individuals are not passive recipients of a predetermined fate. Rather, they make choices that will influence their life chances based on the constraints and resources available to them.

Although all these principles have some implications for current study, two principles—life-span development and linked lives—are particularly important. The life-span perspective points out that development and growth are lifelong processes, and thus, experiences in early childhood have consequences for subsequent life stages (Bengtson 1993; Crosnoe and Elder 2002; Elder et al. 2003). For example, longitudinal evidence suggests that obese children do not 'grow into' their weight and, in fact, BMI tends to track over time (Simmonds et al. 2016). Furthermore, these early events and experiences may operate as a "chain of risks/resources" over the life course, leading to accumulated (dis)advantages over time (Crosnoe and Elder 2002). Consistent with the cumulative disadvantage thesis, early disadvantages in weight status may magnify over time (Serdula et al. 1993), potentially leading to diverging weight trajectories.

The second principle—*linked lives*—concerns the interdependence of lives, particularly in the context of a family, in which individuals are linked across generations by bonds of kinship and processes of intergenerational transmission (Elder 1985; Elder et al. 2003; Hagestad 1981).

The relationships between grandparents and their adult children, and between parents and their young children, are perhaps the most intimate and influential ones. Circumstances such as poverty and low levels of wealth in the grandparents' generation may influence their grandchildren's BMI status directly by shaping the opportunity structure of healthy develop, and indirectly by influencing the socioeconomic status of the adult children (i.e. parents). Therefore, the principle of linked lives provides a strong basis from which to argue that grandparents' wealth may be linked to the BMI growth patterns of their grandchildren.

Grandparents' Wealth and Children's Body Mass Index

Grandparental wealth is a critical SES marker that can be linked to grandchildren's BMI directly, independent of the parent generation. An emerging body of research suggests that the socioeconomic attainments of one generation directly influence the life chances of two or more subsequent generations (Huang et al. 2015; Lê-Scherban et al. 2014; Mare 2011; Mare and Song 2014). One of ways that grandparental wealth shapes grandchildren's BMI directly is through grandparents' assistance in accessing material goods that can mitigate obesity risks. For example, ethnographic research suggests that wealthy grandparents often help their adult parents with home purchases in good neighborhoods or help with education expenses (Oliver and Shapiro 2006; Schneider, Teske and Marschall 2002; Shapiro 2004). Because residential environment can influence heathy food access as well as the opportunities for physical activities, children residing in good neighborhoods often have more playgrounds, sidewalks, and recreational facilities than peers residing in poor neighborhoods (Sallis and Glanz 2006). Wealthy grandparents may also help grandchildren form a healthy lifestyle and diet patterns by providing grandchildren nutritious food or snacks, and by encouraging active life style, and by paying for extracurricular sports activities. In sum, the direct impact of grandparental wealth on grandchildren’s body mass index and the obesity risks may mainly operate through the “purchasing function” of wealth.

Grandparents’ wealth may also influence grandchildren’s BMI indirectly through their influences on the parent-generation. Given family wealth plays a significant role in perpetuating social and economic inequalities from one generation to the next (Conley 1999; Keister and Moller 2000; Killewald, Pfeffer and Schachner 2017; Spilerman 2000), it is not surprising that parental wealth and other types of socioeconomic achievement are shaped by similar resources of their own parents (i.e., grandparents). In particular, wealth is a unique set of resources that can be passed from parents to offspring through inter-vivos transfers (e.g. gifts) and after death in the form of inheritances and bequests (Kohl 2004). The return on capital arising from bequests or gifts enable parents to purchase resources that may enhance children’s accessibility to better nutrition, health, and good housing and neighborhood conditions. All these resources, in turn, may play an important role in preventing children from excessive weight gain or obesity (Grow et al. 2010).

Grandparents’ Wealth and Children’s BMI Growth Patterns

The relationship between grandparental wealth and grandchildren’s BMI growth *patterns* can take at least two forms. On the one hand, the effect of grandparental wealth on grandchildren’s BMI may be stronger in early childhood compared to later developmental stages. This is because early childhood is considered to be a *sensitive period* that has greater biological malleability, and young children also have greater reliance on family’s socioeconomic environment than adolescents (Duncan and Brooks-Gunn 1997, Duncan, Ziol-Guest and Kalil 2010, Shonkoff and Phillips 2000). Therefore, the potential for grandparental wealth to play a role in influencing grandchildren’s body mass index is greater in early childhood than later time points. Children of wealthy grandparents may have access to resources such as healthy food and safe environment that prevent them from obesity risks early in life. In contrast, lack of nutritious food and a safe place for physical activity during early life stages could put children at higher risk of overweight or obesity throughout the life course.

Furthermore, according to DiPrete and colleagues (2006)'s path-dependent model of cumulative advantage, grandparental wealth may play a vital role in shaping grandchildren's early development in body mass index, and the effects of wealth may diminish as children grow and develop. This is because development and growth are self-sustaining process once begun, and a compromised start will perpetuate itself over time, while an initial favorable body weight will feed into later favorable development (Field, Cook and Gillman 2005; Singh et al. 2008). Because BMI growth trajectory is a path-dependent and self-reinforcing process from childhood to adolescence, the potential for grandparental wealth to exert an impact on grandchildren's body mass index, either directly or indirectly, is likely to be greater at the sensitive developmental period in early childhood than mid- to late-childhood years.

On the other hand, however, the effects of grandparental wealth on grandchildren's BMI may strengthen as children grow up, peaking during adolescence and early adulthood. This is because adolescence is a critical time period for forming socio-cultural awareness and behavioral patterns (Blakemore and Mills 2014). The formation of (un)healthy behavior among older children could be shaped and reinforced through the norms, behaviors, and values that their grandparents hold (Blakemore and Mills 2014). Because the direct effects of human capital investment and cultural influence are likely to be minimal in early childhood stages, the effects of grandparental wealth on children's BMI growth patterns are likely to be stronger in later childhood than in earlier years. Table 1 summarizes these three forms of relationships between grandparental SES and grandchild wellbeing.

[Table 1 about here]

Race, Grandparental Wealth, and Grandchildren's Body Mass Index Trajectories

Differences in obesity rate between non-Hispanic blacks and non-Hispanic white children are substantial. Recent estimates indicate that 14% of non-Hispanic white children were obese from 2015-2016, compared to more than 22% of non-Hispanic black children aged between 2 and 19 years old (National center for health statistics 2017). Non-Hispanic white and non-Hispanic black children are exposed to dramatically different levels of grandparental wealth (Gottfredson 1981; Oliver and Shapiro 2006; Portes and Wilson 1976). Whites in general, and well-off whites in particular, are able to accumulate wealth and pass it on from one generation to the next. Just as whites have cumulative advantages in family wealth over generations, blacks may experience cumulative disadvantages in family wealth: blacks generally begin life with few net assets and they may confront structural hardships that obstruct their investment and educational opportunities that are essential to accumulate wealth (Oliver and Shapiro 2006). Given family socioeconomic status is a strong predictor for children's physical development (Morgenstern, Sargent and Hanewinkel 2009; Wells et al. 2010), it is likely that racial disparities in grandparental wealth may account for at least some of the racial differences in BMI and its trajectories between black and white children.

DATA AND METHOD

Data for this analysis are from the Panel Study of Income Dynamics (PSID). Collected and managed by the Survey Research Center of the Institute for Social Research at the University of Michigan, PSID is an ongoing longitudinal survey with a nationally representative sample started with roughly 5,000 families and over 18,000 individuals in 1968. Individuals in these families and their descendants have been followed annually from 1968-1996, and biennially since 1997. In 2013, PSID collected data on 24,952 individuals (of which 17,785 are PSID "sample persons") within 9,063 families. In 1997, the PSID initiated a data collection effort for a cohort of 3,563 children under the age of 13 from 2,394 families in the Child Development Supplement (CDS) (McGonagle et al. 2012). The CDS was designed as a nationally representative sample of children in the United States and oversampled black and low-income families. Subsequent study waves were conducted in 2002–2003 (CDS-II) and 2007–2008 (CDS-III). When CDS participants turn 18 years of age, they become participants in the Transition to Adulthood (TA) survey. They continued to be followed repeatedly and biennially from 2005 to 2013. By 2013, the TA surveys included 2,128 young adults who were 18–27 years old. Together, these supplement surveys collect detailed information about development outcomes among children and young adults in PSID families.

Because family dynamics could be different for children living with parents and those living with grandparents or other relatives, this analysis further limited respondents to children having at least one biological parent living in the household. This is a reasonable selection criterion because information for parental information of children who live with non-parent relatives is likely to be missing. It is important to note that only black and white children and their family members are included in the analytical sample because the number of other race children is small. I then link the CDS-TA respondents (G3) with their parents (G2) and grandparent (G1) from the PSID main survey using the family identification mapping system. The final analytic sample consisted of 1,773 G3 children/youth, of which 1,250 sample members are non-Hispanic white and 523 sample members are non-Hispanic black.

Variables

Body mass index. The heights and weights of the respondents in CDS and TA were measured by the interviewers in person repeatedly at each wave using the same brand of scale and tap. For this analysis, BMI is defined as weight/height^2. In children aged 2 years and older, BMI provides a useful estimate of adiposity that, despite some limitations (Ahima and Lazar 2013), with important health outcomes (Lobstein, Baur and Uauy 2004).

Grandparental wealth. The wealth information was collected in 1984, 1989 and 1994 (as supplements) and 1999 – 2013 waves of the survey. This measure takes into account several sources: net value of the respondent's main home, other real estate, vehicles, any farms or businesses, stocks, IRAs and other financial instruments, cash accounts such as money market funds and certificates of deposit and other assets including value of estates, life insurance policies, pensions and inheritance. Any outstanding mortgage and other debts are subtracted from these assets (PSID 2017). Wealth is calculated in two ways: net financial assets excluding or including home equity. To reduce measurement error, I measure grandparents' family wealth by averaging the wealth (with and without home equity, respectively) between 1984 and 1997. Grandparental wealth ranking is then constructed using the wealth distribution of grandparent generation in the sample. This rank variable ranges from 0 to 1, and a higher value indicates a relative advantage in wealth, and a lower value indicates a relative disadvantage in wealth. In all analyses, I use grandparents' wealth with equity as the primary wealth measure. Sensitivity analyses using wealth without equity generate similar results.

Parents' SES Measures. Similar to the way of constructing the grandparental wealth measure, parents' wealth is measured as an average between 1997 and 2013, and then ranked using the wealth distribution of parent generation in the sample. Additional socioeconomic indicators include parental education, which measured as the highest number of years of education attained by either of the two parents of the CDS child.

Other confounders. I control for a number of confounders. First, to adjust for the potential confounders of the relationship between grandparental wealth and parental SES, I include G1's highest education in year. I also include a series of time-varying covariates to account for the confounding between parental SES and G3 BMI, including family income, maternal BMI, number of children in the household, whether either household head is unemployed, marital status of household head. Also included are the time-invariant demographic characteristics (sex, race, and age) and low birthweight status of G3 respondents, as well as the highest educational attainment in years of either G2 parent.

Method

In order to examine the growth trajectories of children's development, a growth curve analysis is conducted for body mass index (BMI) in the multilevel modeling context (Rabe-Hesketh and Skrondal 2012). In PSID-CDS, up to two children from the same family are randomly selected. Therefore, CDS respondents are nested within parents. Also, because PSID has a genealogical design, parents are nested within their own parents. Given this hierarchical data structure, in this analysis I use three-level growth curve model to estimate the age-based wellbeing trajectories for the CDS children from 1997 to 2013. The analyses have repeated outcome measurements of the grandchildren forming the first level (i.e., within-grandchildren individual effects), grandchildren forming the second level (i.e., between-grandchildren and within-grandparents effects), and grandparents (i.e., between-grandparents effects) forming the third level. The growth curve model allows me to examine how the intercepts and slopes of the outcome trajectories co-vary with the independent variables across individuals. It also allows me to obtain robust standard error estimates for the grandparent-level variables by taking into account the higher-order clusters in the data (i.e., grandchildren nested within grandparents). Finally, it does not require the data to be balanced (i.e., for all children to have the same number of data points).

In this analysis, I first analyze descriptive information to document changes in BMI over time. Growth curve models are used to predict trajectories by child BMI. Age was initiated at the minimum value to facilitate interpretation of the estimated model intercept. I then interact child age and its square term with grandparental wealth ranking to estimate the relationship between grandparents' wealth and trajectories of BMI growth. The interaction term captures age-related change in the relationship between grandparents' wealth ranking and children's BMI.

Following Rabe-Hesketh, Skrondal and Pickles (2005), I use a fixed quadratic random linear model, which is illustrated as follows.

Level 1: $\mathrm{Y} = \pi_0 + \pi_1 Age + \pi_2 Age^2 + \epsilon$

Level 2: $\pi_0 = \beta_{00} + \sum \beta_{0q} \left(X_q\right) + \mu_0$

$$\pi_1 = \beta_{10} + \sum \beta_{1q} \left(X_q\right) + \mu_1$$

$$\pi_2 = \beta_{20}$$

Level 3:

$$\beta_{00} = \lambda_{000} + \lambda_{001} \left(G1wealth\right) + \mu_{00}$$

$$\beta_{10} = \lambda_{100} + \lambda_{101} \left(G1wealth\right) + \mu_{10}$$

The level-1 intercept π_0, the linear slope π_1, the quadratic slope π_2, combine to describe the average trajectories in child development over time. The variance component analyses show that both the intercept π_0 and the linear slope π_1 significantly vary across individuals. Therefore, the model allows π_0 and the linear slope π_1 to vary across individuals and to be predicted by level-2 covariates X_q (not including grandparents' SES, which is a level-3 covariate), where the subscript q represents the qth of level-2 covariate.

RESULTS

Grandparental wealth and grandchild's body mass index trajectories

Table 2 presents the descriptive statistics of the analytical sample by child race (whites versus blacks) when the outcome variable is the repeated measure of body mass index from childhood to early adolescence. The average body mass index (BMI) for all children in the sample is about 23. On average, black children have higher BMI in all survey years than white children. This disparity in BMI is also evident in the parent generation (33.53 versus 25.68). Racial differences in other independent variables are evident. The net wealth for white children's grandparents is $274,000, compared to less than $37,000 for grandparents of black children—that is, grandparental wealth of white children is 7.5 times higher than that of their black counterparts. This wealth disparity between black and white respondents persists in the parent generation. On average, the net parental wealth of black children is only about 20 percent that of their white peers ($95,000 versus $417,000). The average educational attainment for all respondents' grandparents and parents is 12.17 and 13.58 years, respectively. Blacks, again, are disadvantaged in this dimension of socioeconomic status: on average, the educational attainment of black respondents' grandparents and parents are about 2 to 3 years lower than that of white counterparts. Moreover, black children are disadvantaged in several other domains compared to white children. For example, relative to white children, black children have much lower family income, to be born in low birth weight, and more likely to grow up in sing-parent family.

[Table 2 about here]

Table 3 shows the estimates from the growth curve models on the BMI trajectories from 1997 to 2013. The first model is an unconditional growth curve model that estimated the growth trajectories of BMI. In Model 1, the significant positive coefficients (b=0.98, p<0.00) for the linear term of age suggested that BMI grows with age, and the significant negative coefficients for the quadratic term (b=-0.03, p<0.00) and significant cubic term (b=0.00, p<0.00) of age suggested that such growth follows a convex downward-facing curvilinear pattern, with the rate of BMI growth declining with age.

[Table 3 about here]

Model 2 controlled for G1 wealth ranking and Model 3 additionally controlled for G2 wealth ranking. The negative coefficient for G1 wealth ranking for the model intercept indicates that the initial BMI value is lower for child of wealthier grandparents relative to child of less wealthier grandparents. More importantly, the negative and significant coefficient for G1 wealth ranking for the linear growth rate (b=-0.17, p<0.00) shows that the BMI growth rate of children of wealthier grandparents falls substantially below that of less wealthier grandparents, although the positive (yet nonsignificant) G1 wealth ranking coefficient for the quadratic growth rate implies less leveling off in wealthier than less wealthier children's BMI trajectories. Model 3 of Table 18 adds to Model 2 the wealth ranking of parent generation. The positive and large coefficient for G2 wealth ranking for the model intercept (b=3.78, p<0.01) indicates that respondents of wealthier parents tend to have higher BMI in the initial stage than respondents of less wealthier parents. As indicated by its negative and significant coefficient for the linear growth rate and its positive and marginally significant coefficient for the quadratic growth rate, G2 wealth ranking also shapes the trajectory of child BMI over time. Individuals of wealthier parents experience slower than average growth rate as they grow up, and there is less leveling off as G2 wealth increases. Model 3 additionally controlled for parent BMI. The model estimates suggest that G2 BMI is positively and significantly associated with the linear rates of child BMI growth. Moreover, the growth rate of child BMI is faster when child's parent has higher than average BMI, and there is less leveling off as G2 BMI increases. Notably, when adding other G2- and G3-level control variables in the full model, the association between grandparental wealth ranking and the initial status of BMI is attenuated to a nonsignificant level. However, grandparental wealth ranking remains to be associated with the linear rate of their grandchild's BMI growth even with consideration of G2 wealth and BMI status.

To intuitively show how G1 wealth is associated with G3 BMI trajectory, Figure 1 plotted the predicted trajectories of child BMI of G1 wealth at the first, second, and third quartiles of these distributions. As the graph illustrated, group differences in initial BMI at age 4 are trivial. On average, children of lowest G1 wealth have the highest initial BMI status among three groups, and they also have a faster growth rate in BMI relative to the other two groups of higher G1 wealth. In other words, children of higher G1 wealth demonstrated lower initial BMI and a slower BMI growth rate relative to child of lowest G1 wealth.

[Figure 1 about here]

Racial differences in the BMI growth trajectories

To test whether results differ between black and white children, I fit a series of parallel growth curve models separately for white and black children. Table 4 shows the estimates from these race-specific models. The first model for each race group (Model 1 for whites and Model 3 for blacks) controls for G1 wealth, while the second model of each race (Model 2 for whites and Model 4 for blacks) additionally controls for G2 SES factors and G2 BMI, as well as other covariates. Across all models, the significant positive coefficients for the linear term of age suggest that BMI grows with age, and the significant negative coefficients for the quadratic term of age suggested that the rate of BMI increase declining with age. When the coefficients of linear and quadratic growth rate compared, the BMI growth rate is faster for black children than that of white children. Grandparents' wealth is not significantly associated with the initial status of BMI trajectories for both groups. However, grandparents' wealth is significantly and negatively associated with the linear growth rate of BMI for white children but not for black children. For whites, the linear rate of BMI growth would have decreased if the grandchild had a wealthier grandparent. As indicated in Models 2 and 4, G2 wealth and BMI are significantly associated with the rate of BMI growth for white children but not for black children. Adding these G2 and G3 variables also attenuated the coefficients of G1 wealth considerably, indicating that a large part of the growth trajectories of BMI growth is shaped by G2 wealth and BMI status.

[Table 4 about here]

Figure 2 uses the parameter estimates from Models 1 and 3 of Table 4 to graph the growth patterns of BMI for black and white children. As Figure 2 illustrate, there are substantial differences in the initial BMI status and the subsequent growth rate between black and white children. The difference in initial BMI status at age 4 is small. However, white-black difference in the subsequent trajectories of BMI grows as children grow up. By age 26, the BMI of blacks is much higher than that of their white counterparts.

[Figure 2 about here]

In supplementary analysis, I fit a series of models with grandparents' wealth defined as low (lowest quartile of G1 wealth), middle (middle two quartiles of G1 wealth), and high (top quartile of G1 wealth) wealth groups to test whether the results are robust to the coding for G1 wealth. I also used grandparental wealth ranking without home equity as an alternative dependent variable. The supplemental results suggest that the relationships between grandparental wealth and the growth trajectory of child BMI reported here are robust to alternative G1 wealth coding and wealth measure.

CONCLUSION AND DISCUSSION

Life course theory argues that children's developmental trajectories are shaped by larger social contexts and family resources (Elder 1998). Few studies have explicitly examined the intergenerational SES-child wellbeing associations in a three-generation setting. Accordingly, little is known about how family background beyond the nuclear family setting affects children’s development over time. This analysis fills in this gap by investigating the associations between grandparental wealth and child BMI growth patterns.

Results from the growth curve models show that compared to children from more grandparental background, children from disadvantaged grandparental background demonstrated a higher initial BMI, and an accelerated rate of BMI growth from early childhood through adolescence. It indicates that lack of grandparental wealth may put children at risk for excessive weight gain and obesity. This is perhaps because children of low grandparental wealth are more likely to have repeated exposure to energy-dense food and limited access to fruit and vegetables (Drewnowski and Specter 2004; Larson, Story and Nelson 2009) and accordingly tend to develop unhealthy food preferences (Hearn et al. 1998). Furthermore, early childhood is an important period for the individual to develop habits of physical activity that will carry on lifelong. Lack of grandparental wealth during this period can greatly impair children’s development of healthy physical activity habits, primarily because barriers such as limited family and neighborhood resources as poor families often reside in poor neighborhood and school district (Estabrooks, Lee and Gyurcsik 2003; Milteer and Ginsburg 2011). All of these may put children of low grandparental wealth onto a trajectory of accelerated weight gain.

The analysis also suggest that racial differences in the early life course trajectories of BMI are driven partially by the racial differences in wealth accumulation of their grandparents. This is particularly evident for white children who are at relative advantage in grandparental wealth. Broadly consistent with the path-dependent model of cumulative advantage (DiPrete et al. 2006), grandparental wealth of white children plays a vital role in shaping grandchildren's early development in body mass index, and the effects of wealth diminishes as children grow and develop. Accordingly, an initial favorable body weight feeds into later favorable development (Field, Cook and Gillman 2005; Singh et al. 2008). For black children, however, grandparental wealth ranking does not seem to matter significantly for their BMI growth trajectories. Nevertheless, grandparental wealth of black children may have an enduring association with their grandchildren's BMI. Meanwhile, the non-significant association between grandparental wealth and the growth trajectories of BMI among black children may also point to social context, such as neighborhood conditions and health behaviors, as a potential determinant of BMI growth patterns and the subsequent obesity risks for minority children (Kumanyika 2008).

This analysis suggests that grandparental wealth is related to the grandchildren's BMI growth patterns. Future research may benefit from investigating *how* grandparental wealth matter for grandchildren's BMI trajectories. For example, given the strong link between built-in environment and children's body mass index(Frank et al. 2006), future research may investigate whether grandparental wealth effect operate through their help with adult children and their grandchildren move away from poor neighborhood to a better-off community. Doing so holds promise for developing effective intervention programs that reduce child obesity and the racial disparities therein.

Additionally, future research should look beyond the three-generational paradigm. The current study focuses on three-generation framework mostly because of data constraints. However, it is more than likely that the wellbeing of current generation is influenced by the wealth status of previous generations over and above that of parents (Knigge 2016). Some economists estimate that half or more of life time family wealth accumulation can be attributed to past generations in the form of gifts, inheritances, or indirect support (Kotlikoff and Summers 1981; Modigliani 1988). Therefore, wealth may have a particularly long arm in influencing future generations' wellbeing. Future research might benefit from a closer examination of whether and how children's wellbeing in general, and body mass index in particular, are linked to the historical socioeconomic advantages and disadvantages of the previous generations.

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Table 1. Hypothesized forms of the relationship between grandparental wealth and grandchildren's body mass index throughout childhood period

Hypothesis	**Relationship pattern**	**Expected growth curve of grandparental wealth effect**
Enduring (constant) effect	Negative relationship between grandparental wealth and child BMI remains constant with age	The product between grandparental wealth and child age is non-significant
Path dependence	Negative relationship between grandparental wealth and child BMI decreases with age	The product between grandparental wealth and child age is negative
Growing effect	Negative relationship between grandparental wealth and child BMI increases with age	The product between grandparental wealth and child age is positive

Table 2. Descriptive statistics of a three-generation sample used in the analysis of body mass index, by race: Panel Study of Income Dynamics (1968-2013), Child Development Supplement (1997-2007), and Transition to Adulthood Study (2005-2013)

	White grandchildren		Black grandchildren		All grandchildren	
Variable	Mean	SD	Mean	SD	Mean	SD
Dependent Variables						
Body mass index[a]	22.05	4.45	24.78	6.24	22.93	6.06
1997	17.87	3.85	19.62	5.53	18.52	4.68
2002	20.39	5.13	23.13	7.28	21.18	5.99
2005	23.25	3.95	26.67	5.37	24.46	4.84
2007	23.88	4.29	27.46	6.28	25.13	5.34
2009	24.28	4.55	27.77	6.65	25.35	5.44
2011	24.45	4.82	27.87	6.39	25.39	5.46
2013	24.63	5.05	27.24	6.49	25.33	5.52
Independent Variables						
G1 average net wealth (with equity, in 1000s)	274.86	611.70	37.41	45.36	217.23	536.39
G2 average net wealth (with equity, in 1000s)	416.91	1574.26	95.03	302.03	302.21	1269.87
G1 education in years	14.20	3.78	11.46	3.52	12.17	5.28
G2 education in years	14.50	2.86	12.74	2.13	13.58	3.14
G2 family income (in 1000s)	101.54	96.32	54.58	22.48	83.62	104.71
G2 number of kids in the household	1.37	1.18	1.56	1.35	1.48	1.28
G2 body mass index	25.68	4.12	33.53	4.19	28.13	4.04
G2 married	.90	.29	.72	.38	.87	.32
G3 baseline (1997) age	8.45	2.40	8.61	2.40	8.46	2.41
G3 male	.46	.50	.55	.50	.50	.50
G3 low birth weight (<2500 grams)	.05	.22	.12	.33	.08	.25
N of G3 person-periods	3,477		1,423		4,900	
N of G3 persons	1,250		523		1,773	

Notes: G1, first generation (grandparents); G2, second generation (parents); G3, third generation (grandchildren); SD, standard deviation.

[a] Body mass index=weight(kg)/height(m)^2

Table 3. Growth curve models of body mass index (BMI) trajectories in a three-generation sample: Panel Study of Income Dynamics (1968-2013), Child Development Supplement (1997-2011), and Transition to Adulthood Study (1997-2013)

	Child's BMI				
	Model 1	Model 2	Model 3	Model 4	Model 5
Fixed Effects					
Initial BMI status					
Intercept	15.10***	15.65***	15.05***	14.71***	13.02***
G1 wealth ranking		-1.06†	-1.48*	-1.22*	0.04
G2 wealth ranking			3.78**	3.65**	4.26***
G2 BMI				0.16***	0.13**
Linear BMI growth rate					
G3 age	0.98***	1.16***	1.24***	1.21***	1.26***
G1 wealth ranking		-0.17***	-0.15***	-0.13***	-0.13***
G2 wealth ranking			-0.40*	-0.40*	-0.46**
G2 BMI				0.01***	0.01***
Quadratic growth rate					
G3 age^2	-0.03***	-0.03***	-0.03***	-0.03***	-0.03***
G1 wealth ranking		0.01	0.00	0.00	0.01
G2 wealth ranking			0.01†	0.01*	0.01*
G2 BMI				0.01**	0.01**
Cubic term					
G3 age^3	0.00**	0.00**	0.00**	0.00**	0.00**
Control Variables					
Black					1.03
Black * age					1.65***
G3 child is male					0.17
G3 low birth weight					-0.20
G2 Married (at t)					0.15
G2 years of education (at 1997)					-0.01
G2 family income (at t-1)					-0.14
G2 number of kids in the household					-0.00
G2 maternal age (at t)					-0.01
Random Effects Variance Components					
Level 3: between-G1 effects					
Linear slope	0.02***	.04***	0.03***	0.03***	0.03***
Initial status	6.93***	6.10***	6.17***	5.44***	5.45***
Cov (linear slope, initial status)	0.99***	0.95***	0.95***	0.95***	0.95***
Level 2: between-G3 and within-G1 effects					
Linear slope	0.05***	0.03***	0.03***	0.03***	0.03***
Initial status	7.43***	6.77***	6.77***	6.56***	6.46***
Cov (linear slope, initial status)	0.91***	0.89***	0.89***	0.89***	0.87***
Level 1: within-G3 effects	6.14***	5.91***	5.89***	5.92***	5.68***
Goodness-of-fit					
BIC	36115.48	23828.93	23810.78	23660.23	19222.06
N of G3 person-periods	4,900	4,900	4,900	4,900	4,900
N of G3 observation	1,773	1,773	1,773	1,773	1,773

Note: † p<0.1, * p<0.05, ** p<0.01, *** p<0.001

Table 4. Growth curve models of body mass index (BMI) trajectories in a three-generation sample, by race: Panel Study of Income Dynamics (1968-2013), Child Development Supplement (1997-2011), and Transition to Adulthood Study (1997-2013)

	White		Black	
	Model 1	Model 2	Model 3	Model 4
Fixed Effects				
Initial BMI status				
Intercept	14.60***	13.69***	16.52***	13.85***
G1 wealth ranking	1.63	0.70	-0.18	1.28
G2 wealth ranking		3.01*		4.31
G2 BMI		0.06		0.22
Linear BMI growth rate				
G3 age	1.14***	1.19***	1.23***	1.41***
G1 wealth ranking	-0.33*	-0.17*	-0.42	-0.53
G2 wealth ranking		-0.37*		-0.40
G2 BMI		0.03*		0.00
Quadratic growth rate				
G3 age^2	-0.03***	-0.03***	-0.03***	-0.03***
G1 wealth ranking	0.01†	0.00	0.01	0.02
G2 wealth ranking		0.01*		0.01
G2 BMI		0.00		-0.00
Control Variables				
G1 education		-0.02		-0.01*
G3 low birth weight		-0.61		-0.24
G3 child is male		0.42*		-0.81
G2 married (at t)		-0.48*		1.06*
G2 years of education (at 1997)		0.01		-0.05
G2 family income (at t-1)		-0.00		0.00
G2 maternal age (at t)		-0.03		-0.02
Random Effects Variance Components				
Level 3: between-G1 effects				
Linear slope	0.03**	0.03**	0.01***	0.00***
Initial status	2.62***	2.20***	12.62***	12.54***
Cov (linear slope, initial status)	0.05***	0.03***	-0.14***	-0.22***
Level 2: between-G3 and within-G1 effects				
Linear slope	0.02**	0.02**	0.07**	0.07**
Initial status	5.80***	5.66***	9.98***	10.86***
Cov (linear slope, initial status)	-0.11***	-0.12***	-0.11***	-0.24***
Level 1: within-G3 effects	4.92***	4.84***	10.46***	10.37***
Goodness-of-fit				
BIC	16730.56	16473.71	5856.965	5578.949
N of person-periods	3,477	3,477	1,423	1,423
N of persons	1,250	1,250	523	523

Note: † p<0.1, * p<0.05, ** p<0.01, *** p<0.001

Figure 1. Predicted trajectories of children's BMI growth, by G1 levels of wealth

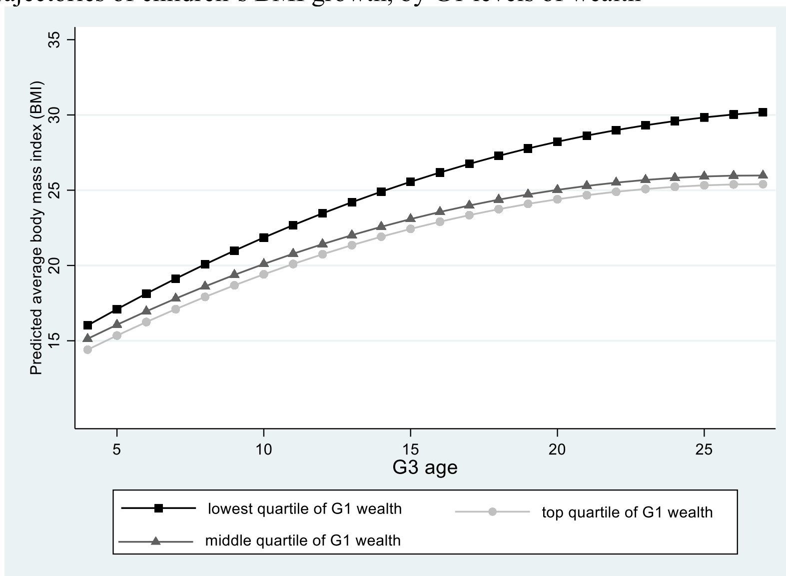

Figure 2. Predicted trajectories of children's BMI growth, by race