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Qi Zhang
Old Dominion University

Buhong Zheng

Ning Zhang

Youfa Wang

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SOCIOECONOMIC STATUS AND HEALTH ACROSS GENERATIONS AND OVER THE LIFE COURSE

Decomposing the Intergenerational Disparity in Income and Obesity

Qi Zhang* Buhong Zheng†
Ning Zhang‡ Youfa Wang**

*Old Dominion University, qzhang@odu.edu
†University of Colorado at Denver, buhong.zheng@ucdenver.edu
‡University of Rochester, ning_zhang@urmc.rochester.edu
**Johns Hopkins University, ywang@jhsph.edu

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Decomposing the Intergenerational Disparity in Income and Obesity*

Qi Zhang, Buhong Zheng, Ning Zhang, and Youfa Wang

Abstract

Intergenerational disparity in income and health violates the norm of equal opportunity and deserves the attention of researchers and policy makers. To understand changes in intergenerational disparity, we created the intergenerational mobility index (IMI), which can simultaneously measure changes in income rankings and in health outcomes across two generations. We selected obesity as one health outcome to illustrate the application of IMI due to its severe health and financial consequences for society and the significant changes in the distribution of obesity across income groups. Although obesity has increased in all income groups in the last four decades, higher income groups have tended to have a faster increase in obesity, which has reduced the disparity in obesity across income groups. The strength of our intergenerational approach within families is to control the genetic influence, which is one of the strongest determinants of obesity. The decomposition of the IMI illustrates that it captures changes in obesity distribution (holding constant income rankings between generations) and changes in income rankings (holding constant the obesity distribution across generations), simultaneously. We used the data of the Panel Study of Income Dynamics (PSID), which have been collected since 1967, is the longest longitudinal survey in the U.S. The PSID surveyed respondents' height and weight were recorded in 1986 and from 1999 to 2007. We selected respondents from 1986 as the parental generation and respondents from 2007 as the adult children's generation. To make the adult children's body weight status and income comparable to their parents', we stratified the analysis by gender. For the pairs of fathers and adult sons, we found the intergenerational disparity in overweight, a less severe indicator of excessive fatness, across income was decreasing. This was partially due to the up-swing in the adult children's income status. For the pairs of mothers and adult daughters, we found a similar decrease in socioeconomic disparity in obesity. However, decomposition of the IMI indicated that changes in income distributions between mothers and adult daughters contributed smaller effects than that between fathers and adult sons. Our study has demonstrated that the IMI and its decomposition are useful tools for analyzing intergenerational disparity in income and health.

KEYWORDS: obesity, intergenerational disparity, socioeconomic status, income distribution, concentration index

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INTRODUCTION

There is continued interest in how human capital is transmitted from one generation to the next. The norm of equal opportunity assumes the equality of human capital. However, the transmission of human capital from parents with different socioeconomic status may violate this norm in a society, and this deserves policy interventions. Previous literature has focused primarily on the intergenerational correlation of wealth and income mobility (Solon, 1992; Chadwick and Solon, 2002; Nardi, 2004). Solon (1992) suggested a value of 0.4 in the long-run income correlation between fathers and sons, indicating a low mobility across generations. A parallel analysis suggested the intergenerational transfer of wealth between mothers and daughters was weaker than between fathers and sons (Chadwick and Solon, 2002). Nardi (2004) further argued that a significant transfer in productivity exists across generations as well. Black et al. (2005) extended the research by examining intergenerational changes in educational status and found that higher maternal education reduced the efforts and costs required to educate children.

Limited research has been conducted regarding intergenerational transfer of health and income simultaneously. Ahlburg (1998) argued that the correlation of income across generations partially resulted from the transfer of education and health between parents and children. Currie and Moretti (2007) found a strong correlation between family poverty status and low birth weight in children born to these families. Although there was sufficient evidence of health disparity across socioeconomic status in each generation, few studies have directly assessed changes in socioeconomic disparity across generations, and most of these studies rely on regression coefficients to interpret the intergenerational correlation of socioeconomic disparities. The limitation of regression coefficients in measuring disparity is that coefficients are indicators of the average strength of the relationship but do not reflect disparity directly (Zhang and Wang, 2004a). In this paper, we have created a new index, the Intergenerational Mobility Index (IMI), as a measure to capture the changes in health distribution while income ranking also changes across generations. In addition, we have derived the decomposition of the IMI, showing that changes in overall health disparities across income groups were a weighted sum of changes in income disparities and health disparities across generations. To illustrate the usefulness of the IMI and its decomposition, we selected obesity, an important health problem in the U.S.

Obesity has severe health and financial consequences for society. Obese individuals have greater risks of chronic diseases, such as cardiovascular disease, type 2 diabetes and hypertension (WHO, 2000). An estimated 300,000 annual deaths can be linked to obesity in the U.S. (Allison, 1999). In the last four decades, the increase in obesity was significant across socio-demographic groups; currently one third of Americans are obese (Zhang and Wang, 2004b; Flegal et al., 2010). The total medical costs associated with obesity were estimated to be $92.6 billion in 2002 (Finkelstein, Fiebelkorn and Wang, 2003). If the current trend in obesity persists, total medical costs attributable to obesity would double every decade, comprising 16~18% of U.S. medical costs by 2030 (Wang et al., 2008).

In developed countries like the U.S., adults with low socioeconomic status (SES) have had a higher risk of obesity than their counterparts with high SES (Sundquist and Johansson, 1998). Given the significant increase in obesity rates in the last three decades (Flegal et al., 2010), it is important to examine the changes in obesity rates across SES. Our original studies suggested that all SES groups have become more obese in the last three decades, and higher-SES adults are getting obese relatively faster than lower-SES adults (Zhang and Wang, 2004b). The shrinking obesity gap between low- and high-SES groups has also been documented in different subpopulation groups (Clarke et al., 2009; Singh et al., 2011; Walsemann and Ailshire, 2011). The methods of all these papers were regression-based, which was not a direct measure of socioeconomic inequality in obesity. We have pioneered the use of the Concentration Index (CI) to study the trends of socioeconomic inequality in obesity. Our studies have suggested that although all socioeconomic groups have become more obese, the higher SES groups have been getting obese faster, which has reduced the socioeconomic inequality in obesity (Zhang and Wang, 2004c, 2006, 2007).

These studies used either multiple cross-sectional data or panel data to examine the general population over time but did not strictly examine the intergenerational changes within one family, e.g., comparing fathers and their adult sons directly. The strength of an intergenerational approach within families is to control for the genetic influence, which is one of the strongest determinants of obesity (Li et al., 2009), so that we are able to examine non-genetic factors that are modifiable and may be used to reverse the trends in obesity. In this study, we used the CI to measure the socioeconomic inequality of obesity in parental generations and their offspring generations, which advanced our understanding of changing socioeconomic inequality of obesity from our previous studies focusing on general populations (Zhang and Wang 2004b, c).

A problem with the literature to date is that it has only documented the shrinking gaps in obesity rates across SES but has rarely explained what factors are contributing to the trends. In this study, we created the IMI, which measures changes in parental CIs and offspring CIs. The IMI can be mathematically decomposed into two parts: one part reflecting changes in obesity across SES assuming that the offspring's income distribution is identical to their parents'; the other part reflecting changes in socioeconomic inequality in obesity purely from changes in income distribution. Conceptually, changes in socioeconomic inequality of obesity can come from two sources: If there is no change in the income ranking, obesity grows faster or slower in low income groups than in high income groups so the disparity of obesity across the income distribution can increase or decrease. However, if the obesity status stays the same for each individual but the individual's relative income changes, the disparity of obesity across the income distribution can still change. In the next section, we illustrate the decomposition in mathematical terms.

METHODS

Theory of Concentration Curve and Concentration Index

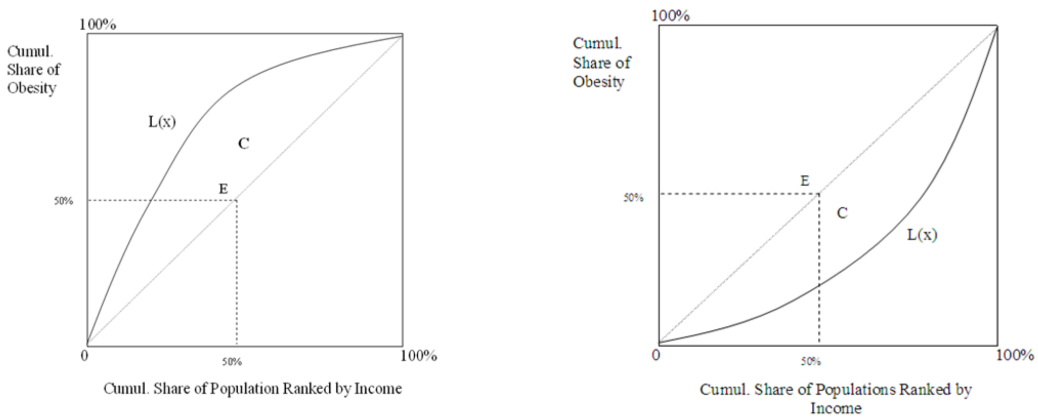
Zhang and Wang (2004a) first applied the Concentration Index to measure socioeconomic disparity in obesity. The Concentration Index is different from the well-known Gini coefficient in that the Gini coefficient concerns the unequal distribution of a single variable (for instance, obesity or income), while the Concentration Index measures the unequal distribution of one variable (obesity) with respect to a second variable (income). In other words, the Concentration Index measures socioeconomic inequality of obesity due to unequal income distribution, while the Gini index simply measures the inequality of obesity. Figure 1 illustrates the theory behind the concentration curve and the Concentration Index. In Figure 1(a) and (b), the cumulative proportion of the population, ranked by income from the poorest to the richest (0-100% of the total population), was plotted against the cumulative proportion within the obese population, from the lowest to the highest (0-100% of the obese individuals within the population). The resulting curve is referred to as the obesity concentration curve *L(x)*, where x means the cumulative share of obesity among the population.

If *L(x)* coincides with the diagonal, the obesity burden is equally distributed across income levels. For example, the bottom 50% of the people in the income distribution account for 50% of the obese individuals in the population. In that case, there is no socioeconomic disparity in obesity. Therefore, the diagonal is also known as the "egalitarian line." If the concentration curve lies above the diagonal (as seen in Figure 1a), obesity is more concentrated among the low-income population. If the concentration curve lies below the diagonal (as seen in Figure 1b), obesity is more concentrated among the high-income population. The degree of inequality is measured by the area between *L(x)* and the egalitarian line. We can define the Concentration Index (*CI*) as twice the area (Area *C*) between the *L(x)* and the diagonal. Mathematically, Wagstaff et al. (1991) suggested that the Concentration Index can be calculated as follows:

$$CI = \frac{2}{\bar{y}} Cov(y, R) \qquad (1)$$

Where y is the obesity status of an individual and R is the relative rank of that individual in the income distribution from the poorest to the richest. $\bar{y}$ is the mean level of obesity in the population. The value of the *CI* ranges from -1 to +1. A negative *CI* value means that obesity is more concentrated among lower-income groups, while a positive *CI* value means that obesity is more concentrated among high-income groups. The value of -1 means all obesity burdens are concentrated on the poorest person in the population, while the value of +1 means all obesity burdens are concentrated on the richest person. If the Concentration Curve is the diagonal, the *CI* equals zero, which means there is no socioeconomic disparity in health.

Figure 1. Concentration Curves of Obesity



(a). Obesity is more concentrated among low-income groups

(b). Obesity is more concentrated among high-income groups

The Intergenerational Mobility Index (IMI) of Obesity

We assume two generations: parents and children. Since the mobility of human capital is gender specific (Solon, 1992), we analyzed the IMI in two pairs: fathers and adults sons, mothers and adult daughters. In the following derivations, we only use obesity between fathers and adult sons for illustrative purpose and for convenience. We use *f* to represent the father's generation and *s* to represent the son's generation. Each father has an obesity status indicator, y^f, and a relative rank, R^f, in his generation's income distribution. Similarly, each son has an obesity status indicator, y^s, and a relative rank, R^s, in his generation's income distribution. Assume that we only consider biological fathers and sons, so each son has only one biological father. We assume that there are *N* pairs of sons and fathers, where

N is the number of sons. Average obesity statuses in the father's and the son's generations can be calculated as follows:

$$\bar{y}^f = \frac{\sum_{i=1}^{N} y^f}{N} \qquad (2)$$

$$\bar{y}^s = \frac{\sum_{i=1}^{N} y^s}{N} \qquad (3)$$

Step 1: Calculate the *CI* for obesity for the fathers and for the sons, which shows how obesity is distributed across income at two points in time:

$$CI^f = \frac{2}{\bar{y}^f}\mathrm{cov}(y^f, R^f) \quad (4)$$

$$CI^s = \frac{2}{\bar{y}^s}\mathrm{cov}(y^s, R^s) \quad (5)$$

Step 2: Calculate the Intergenerational Mobility Index (*IMI*), which is the difference between CI^f and CI^s and shows the changes of CI over time.

$$IMI = CI^f - CI^s \quad (6)$$

Figure 2 illustrated the *IMI* as twice the area between $L^f(x)$ and $L^s(x)$, which depends on the relative distributions of obesity across income between the father's and the son's generations.

Step 3: Decomposition of *IMI* (the complete derivation is attached in the Appendix):

$$IMI = (CI^f - CI^{sf}) + (CI^{sf} - CI^s)$$

$$= 2\sum_i \left(\frac{y^f}{\bar{y}^f} - \frac{y^s}{\bar{y}^s}\right)\left(R^f - \frac{1}{2}\right) + 2\sum_i \left(\frac{y^s - \bar{y}^s}{\bar{y}^s}\right)\left(R^f - R^s\right) \qquad (7)$$

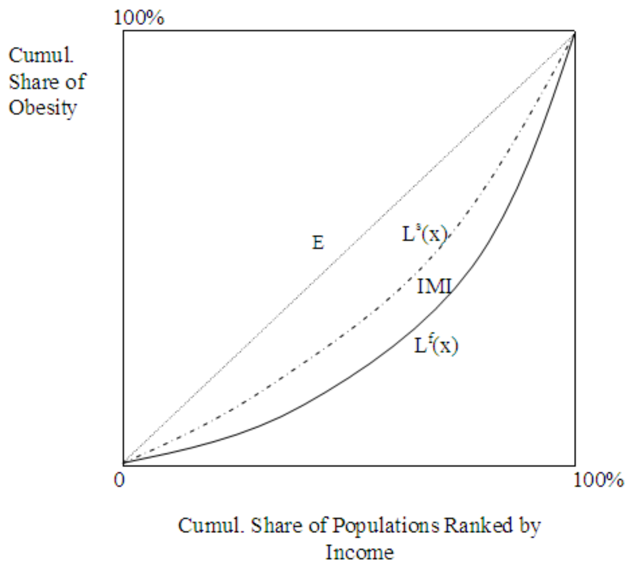
Where $CI^{sf} = \frac{2}{\bar{y}^{sf}}\mathrm{cov}(y^s, R^f)$ and $\bar{y}^{sf} = \frac{\sum_{i=1}^{N} y^s}{N}\,\bar{y}^s$

Note that CI^{sf} is the hypothetical index if the son's income ranking is identical to the father's income ranking,

$\left(\frac{y^f}{\bar{y}^f} - \frac{y^s}{\bar{y}^s}\right)$ is the normalized obesity difference across two generations,

$\frac{y^s - \bar{y}^s}{\bar{y}^s}$ is the standardized son's obesity status, and $(R^f - R^s)$ is the difference in intergenerational income ranking.

Figure 2. Graphic Presentation of Intergenerational Mobility Index (*IMI*)



Note: *$L^f(x)$* represents the concentration curve of the father's generation; *$L^s(x)$* represents the concentration curve of the son's generation.

The decomposition of equation (7) also reveals the factors that *IMI* can capture: the change in obesity distribution across generations and the change in relative income positions. Specifically, the first part of equation (7), $(CI^f$ - $CI^{sf}) = 2\sum_i \left(\frac{y^f}{\bar{y}^f} - \frac{y^s}{\bar{y}^s}\right)(R^f - \frac{1}{2})$, indicates that the intergenerational difference in the normalized obesity status and the scale of measure will depend on whether obesity grows more at the lower or the upper part of the income distribution. If there is no difference in fathers' and sons' obesity status, this part equals zero. The second part of equation (7), $(CI^{sf}$ - $CI^s) = 2\sum_i \left(\frac{y^s - \bar{y}^s}{\bar{y}^s}\right)(R^f - R^s)$, isolates the impact of changes in the income rankings across generations. It equals zero if the son's relative ranking and the father's relative ranking are identical.

Data

We used the Panel Study of Income Dynamics (PSID) to compute IMI for two reasons: First, the PSID began in 1968 and is the longest longitudinal study of representative U.S. individuals and their families, successfully following children of the interviewed families into adulthood and the formation of their own families. Second, the PSID has extensive information about income and health across the survey years. Not only has the PSID surveyed household income each year, it also surveyed the household heads' and their spouses' height and weight in 1986 and in 1999-2007.

To make parental and children's body weight statuses comparable, we used 1986 for the parental generation and 2007 as the adult children's generation. We limited the ages of the respondents to between 25 and 45, since adult body weight status and income are relatively stable for that age group and the age group is similar to that used in previous literature on income mobility (Solon, 1992; Kahn et al., 1997). The reasons to select 2007 as the adult children's generation are because: a) 2007 is the latest wave available in the PSID; b) 2007 gave the largest sample size of eligible adult children, and sample size is a challenge to most intergenerational studies; and c) given that age is an important factor in human development and body weight status, we would like to have two waves at comparable ages. The difference between mean age of the parents and mean age of the adult children was minimized in 2007. We merged 1,123 fathers aged 25-45 in 1986 with their 1,629 sons aged 25-45 in 2007. Similarly, we found 451 mothers aged 25-45 in 1986 and matched them with their 675 daughters aged 25-45 in 2007. We excluded adults whose records did not indicate their body height and weight.

Measurement and Statistical Analysis

Body Mass Index (*BMI*) was defined as weight [kg] / height^2 [m], overweight was defined as a *BMI* greater than or equal to 25, and obesity was defined as a *BMI* greater than or equal to 30. We used household income as the ranking variable for the income distribution, since household income is related to a family's food choices and therefore to body weight status (Zhang and Wang, 2004c). We also used the per capita income, which generated similar results. Since income is only a ranking variable to calculate the Concentration Index, there is no need to adjust for inflation across time.

We present the demographic and socioeconomic characteristics by gender and generations. In this paper, we only focus on the *IMI* and the decomposition between income and health; we leave the further derivation of decomposition across demographics for a future study. Therefore, we will not control for demographics in this paper. Sampling weights for 1986 and 2007 were applied in the analysis. The *CI*s of obesity and overweight were calculated for both the parents' and the adult children's generations. The inference tests of *CI* in Bishop et al. (1998) were applied. We presented the *IMI* based on both overweight and obesity definitions and the two parts in the decomposition of the *IMI*. It is important to test whether the *IMI*s are statistically significantly different from zero. Therefore, we bootstrapped the confidence level to statistically test the hypothesis whether the *CI*s were significantly different across generations.

RESULTS

Table 1 presents the socio-demographic results of the matched parents and their adult children. 1,629 pairs of fathers and sons and 675 pairs of mothers and daughters were identified. Among them, there were 1,123 unique fathers and 451 unique mothers. The matching rate among mothers and daughters was significantly lower than that among fathers and sons. Parental race was used to identify children's race. Fathers' race composition was similar to the demographics in the U.S. in 1986, while minority mothers were significantly more weighted in the mother-daughter matching. Household income also indicated that father-and-son pairs were closer to representative of the U.S. population, while mothers and daughters were heavily concentrated in the low-income group. Education composition indicated similar results.

The mean *BMI* of fathers was 26.8, which was close to the national average in the late 1980s (mean *BMI* = 26.5) (Zhang and Wang, 2004b). The mean *BMI* of sons increased to 28.8 in 2007, a 7.4% increase from that of fathers. The prevalence of overweight across generations increased from 62.8% to 78.8%, an approximately 25.5% increase. The increase in obesity between the two generations was much more severe. In 1986, the prevalence of obesity among fathers was 18.2%, while the prevalence among sons in 2007 was 33.6%, which was almost an 85% increase. This means that the obesity problem became much worse in the adult sons' generation.

The mean *BMI* of mothers in the late 1980s was 27.8, slightly higher than the national average at that time, which was 26.3 (Zhang and Wang, 2004b). The mean *BMI* of daughters increased 9% to 30.3. The intergenerational change in prevalence of overweight increased from 63.1% in the mothers' generation to 76.43% in the daughters' generation. The obesity rate increased from 30.7% in mothers to 43.4% in daughters, an approximately 41.5% increase across the two generations. Overall, the change in overweight rates was larger, but changes in obesity rates were smaller between mothers and daughters than between fathers and sons.

Table 2 presents the *CI*s of obesity and overweight in two generations. The fathers had a significant socioeconomic disparity in obesity and overweight. Both *CI*s were significant at the 1% level. However, the direction of the disparity depended on whether it was measured by obesity or by overweight. Obesity was more concentrated in lower-income groups in the fathers' generation (CI^f = -0.097), while overweight was more concentrated in higher-income groups (CI^f = 0.031). This reflected the difference in socioeconomic disparity in obesity measured by different *BMI* cut-off points. In the sons' generation, the socioeconomic disparity in obesity mimicked the pattern in the fathers' generation, while the *CI* of obesity was negative (-0.033), but the *CI* of overweight was positive (0.032). The disparity in overweight was statistically significant in the sons' generation, but that in obesity was only marginally significant (P = 0.08). However, if there were no changes in income distribution across the sons' and the fathers' generations, then the socioeconomic disparity in obesity was highly significant (CI^{sf} = -0.087, $P < 0.01$); the same significant results were found if measured in overweight as well. Therefore, our study indicated that changes in income distributions could significantly affect the measurement of socioeconomic disparity in obesity across generations.

Table 1. Sociodemographics and Body Weight Status in Matched Parents and their Adult Children

	Fathers	Sons	Mothers	Daughters
Year	1986	2007	1986	2007
N	1123	1629	451	675
Age (mean)	44.71	38.83	46.51	41.97
Parental Race (%)				
White	76.78	-	31.61	-
Black	19.98	-	65.51	-
Others	3.24	-	3.88	-
Education (%)				
Less than high school	24.78	12.75	99	64.68
High school graduate	29.33	26.02	0.28	10.52
College or above	45.89	61.23	0.74	24.8
Body Mass Index (mean)	26.81	28.80	27.82	30.32
Overweight (BMI >= 25) (%)	62.76	78.78	63.1	76.43
Obesity (BMI >= 30) (%)	18.17	33.60	30.69	43.42

The *IMI* in obesity between fathers and sons was -0.064, indicating that socioeconomic disparity in obesity in the sons' generation was reduced compared with the disparity in the fathers' generation. The IMI of obesity in fathers and sons was marginally significant (P = 0.08). These findings were consistent with our previous results on the trends in the association between socioeconomic status and obesity in U.S. adults (Zhang and Wang, 2004b, 2004c). However, the *IMI* of overweight was close to zero and without significance, which indicated that the distribution of overweight burden across income groups did not change significantly across generations.

Table 2. Intergenerational Mobility Index in Obesity and Overweight between Fathers and Sons

	Obesity	SE	P-value	Overweight	SE	P-value
CI^f	-0.097	0.036	<0.01	0.031	0.012	<0.01
CI^{sf}	-0.087	0.025	<0.01	-0.036	0.008	<0.01
CI^s	-0.033	0.024	0.08	0.032	0.009	<0.01
IMI (CI^f-CI^s)	-0.064	0.045	0.08	-0.001	0.017	0.47
CI^f-CI^{sf}	-0.010	0.037	0.39	0.067	0.016	<0.01
CI^{sf}-CI^s	-0.054	0.036	0.07	-0.068	0.013	<0.01

In summary, the *IMI* suggested a weakly reduced socioeconomic disparity in obesity but not in overweight. To answer our original questions about how to interpret the results, the decomposition of the *IMI* is needed. In Table 2, the difference between CI^f and CI^{sf} measures only the change in body weight status between fathers and sons, since both *CI*s use the same income rankings across two generations. Interestingly there was almost no significant change in the distribution of obesity across income levels in the two generations (CI^f - CI^{sf} = 0.010). Note that the insignificant difference does not mean that sons were as heavy as their fathers. Although adult sons were more obese than their fathers, as indicated in *BMI* and obesity rates, the disparity in the obesity distribution across income groups did not significantly shift if the income distribution did not change. On the other hand, if all the sons' income distribution shifted from their fathers' income to their own income, the difference in *CI*s (CI^{sf} – CI^s) was -0.054 and marginally significant (P = 0.07). The negative difference indicated that more equalized income distribution mainly causes the reduction in intergenerational socioeconomic disparity in obesity. In summary, our results show that changes in income distribution across generations could affect the measurement of socioeconomic disparity in obesity.

Table 2 also indicates the importance of different measurements of body weight status. The difference of CI^f and CI^{sf} in overweight was highly significant and positive (0.067), indicating a striking shift of overweight burden towards low-income groups ($P < 0.01$). Overweight has a lower *BMI* cut-off point than obesity, so the shift of overweight burden was more general than the shift of obesity burden. Although there was an absolute change in overweight disparity even when controlling for income, the shifting income distribution still contributed a portion of the *IMI*. The difference of CI^{sf} and CI^{s} was significantly negative (-0.068, $P < 0.01$). The results indicated that a more equalizing income distribution in the sons' generation actually offset the portion of the disparity in overweight if income did not change (-0.068 vs. 0.067). In other words, if sons' incomes were the same as their fathers' incomes, the intergenerational mobility could be more dramatic than the current value of the *IMI* (0.001). The decomposition of the *IMI* suggests that the burden of overweight had a significant shift toward lower income groups, but a more equalized income distribution in the son's generation offset the disparity, which resulted in an almost zero *IMI*.

Table 3 presents the *CI*s of obesity and overweight in mothers and adult daughters. All *CI*s of the two generations were significantly negative, indicating that overweight and obesity were more concentrated in lower-income groups in both generations. If the daughters' income were replaced by the mothers' income, obesity and overweight became less concentrated in lower-income groups, since the *CI*s were negative and the absolute value of CI^{sf} was less than CI^{s}.

Table 3. Intergenerational Mobility Index in Obesity and Overweight between Mothers and Daughters

	Obesity	SE	P-value	Overweight	SE	P-value
CI^{m}	-0.200	-0.049	<0.01	-0.095	0.022	<0.01
CI^{md}	-0.097	0.035	<0.01	-0.026	0.016	0.05
CI^{d}	-0.134	0.034	<0.01	-0.033	0.016	0.02
$IMI\ (CI^{m}\text{-}CI^{d})$	-0.066	0.064	0.15	-0.062	0.037	0.04
$CI^{m}\text{-}CI^{md}$	-0.103	0.071	0.07	-0.069	0.031	0.01
$CI^{md}\text{-}CI^{d}$	0.037	0.056	0.75	0.007	0.029	0.59

The *IMI*s of obesity and overweight across mothers' and daughters' generations were both negative, and the IMI of overweight was significant (P = 0.04), indicating that the socioeconomic disparity in overweight and obesity decreased from the mothers' generation to the daughters' generation. The pattern of decreasing socioeconomic disparity in obesity and overweight among mothers and daughters was consistent with the pattern found among fathers and sons. The decomposition of the *IMI* further explained the reasons for this decreasing disparity. If there was no change between the mothers' and the daughters' income distributions, we would see a larger decrease in socioeconomic disparity. (The absolute value of $CI^{m} - CI^{md}$ was greater than the absolute value of the *IMI*.) However, due to the more unequal income distributions among daughters, the component of $CI^{md} - CI^{d}$ offset the decrease in socioeconomic disparity. As distinct from fathers and sons, the income component of *IMI* ($CI^{md} - CI^{d}$) was only a small portion of the health component of *IMI* ($CI^{m} - CI^{md}$), which suggests the shift in obesity or overweight distribution is dominant in the *IMI*. Although there is a slight change due to the changes in income distribution, it is not significant.

DISCUSSION AND CONCLUSIONS

Social scientists have long realized the importance of the intergenerational transmission of human capital (Solon, 1992; Ahlburg, 1998; Chadwick and Solon, 2002; Black et al., 2005). Income and health are important components in the intergenerational transfer, and there is a significant relationship between income and health. The challenge is to be able to measure simultaneous changes in income and health across generations. In this paper, we propose the Intergenerational Mobility Index (*IMI*) based on the Concentration Index approach to quantify the changing disparity in health status across income distributions in two generations. The Concentration Index is one of the most commonly used measures in studies of socioeconomic disparity in health (Wagstaff et al., 1991), but few researchers have used it to measure intergenerational shifts in health. Not only have we created the *IMI*, we have also derived a two-part decomposition of it. The decomposition self-explains two possible sources of changes in socioeconomic disparity: Intergenerational changes in health status will change socioeconomic disparity, while shifting income distribution itself will also contribute to intergenerational disparity in health. This decomposition further illustrates the meaningfulness of the *IMI*.

We have applied the newly developed *IMI* and two-part decomposition to the issue of obesity, which has become a significant public health problem in the U.S. in the last four decades (Zhang and Wang, 2004b). Our previous studies suggested that there was a declining socioeconomic disparity in obesity (Zhang and Wang, 2004b, 2004c, 2007). Between fathers and sons, the overall *IMI* had achieved a reduction of marginal significance. However, the decomposition of the *IMI* among fathers and sons suggested that the distribution of obesity did not show a significant change if the income distribution were the same in the two generations. Changes in income ranking in the two generations contributed the most to the *IMI*. If socioeconomic disparity is measured in terms of overweight, we find the effect of changes in income ranking almost totally offset the effect of changes in obesity distribution across generations. Note that previous studies did not use the concept of "generation," i.e., fathers can still be counted in the socioeconomic disparity if they survive to the generation when their children become adults. Therefore, previous literature did not differentiate between generations but counted all living adults. This paper partially addresses this concern and clearly uses the matched pairs of fathers and sons in two generations.

Since our main purpose is to propose a new method for calculating the intergenerational disparity in income and health, our empirical results have to be interpreted carefully. First, few datasets can be used to calculate the *IMI*. The appropriate data needs to have both generations' income and health measurements, which have not been collected in most studies. Second, although the PSID was designed to be nationally representative, our matched sample was no longer nationally representative, especially between mothers and daughters. Therefore, our results were informative for understanding the changing disparity in obesity across generations but were not designed to fully explain national trends in socioeconomic disparity in obesity. Actually, our paper calls for more large-scale collections of longitudinal data that include more intergenerational socioeconomic and health measures.

In conclusion, we present a new index to quantify the mobility of intergenerational transfer in human capital. The decomposition of the new index is meaningful for understanding the sources of changing disparity in health across income distributions. The index can be more generally applied to different health measures, which will provide us with more knowledge about the intergenerational transfer of human capital.

APPENDIX: THE DECOMPOSITION OF *IMI*

$$IMI = CI^f - CI^s = (CI^f - CI^{sf}) + (CI^{sf} - CI^s) \quad \text{(A1)}$$

Where $CI^{sf} = \frac{2}{\bar{y}^{sf}}\text{cov}(y^s, R^f)$ and $\bar{y}^{sf} = \frac{\sum_{i=1}^{N} y^s}{N}\,\bar{y}^s$

$$CI^f - CI^{sf} = \frac{2}{\bar{y}^f}\text{cov}(y^f, R^f) - \frac{2}{\bar{y}^s}\text{cov}(y^s, R^f)$$

$$= \frac{2}{\bar{y}^f}\sum_i (y^f - \bar{y}^f)\left(R^f - \tfrac{1}{2}\right) - \frac{2}{\bar{y}^s}\sum_i (y^s - \bar{y}^s)\left(R^f - \tfrac{1}{2}\right)$$

$$= \left[\frac{2}{\bar{y}^f}\sum_i (y^f - \bar{y}^f) - \frac{2}{\bar{y}^s}\sum_i (y^s - \bar{y}^s)\right]\left(R^f - \tfrac{1}{2}\right)$$

$$= 2\sum_i \left(\frac{y^f}{\bar{y}^f} - 1\right)\left(R^f - \tfrac{1}{2}\right) - 2\sum_i \left(\frac{y^s}{\bar{y}^s} - 1\right)\left(R^f - \tfrac{1}{2}\right)$$

$$= 2\sum_i \left(\frac{y^f}{\bar{y}^f} - \frac{y^s}{\bar{y}^s}\right)\left(R^f - \tfrac{1}{2}\right) \quad \text{(A2)}$$

$CI^{sf} - CI^{s} = \frac{2}{\bar{y}^s}\text{cov}(y^s, R^f)$ - $\frac{2}{\bar{y}^s}\text{cov}(y^s, R^s)$

$= \frac{2}{\bar{y}^s}\sum_i (y^s - \bar{y}^s)\,(R^f - \frac{1}{2})$ - $\frac{2}{\bar{y}^s}\sum_i (y^s - \bar{y}^s)\,(R^s - \frac{1}{2})$

$= \frac{2}{\bar{y}^s}\sum_i (y^s - \bar{y}^s)\,(R^f - R^s)$

$$=2\sum_i \left(\frac{y^s - \bar{y}^s}{\bar{y}^s}\right)(R^f - R^s) \qquad \text{(A3)}$$

Therefore,
IMI = CI^f - CI^s=(CI^f - CI^{sf}) + (CI^{sf} - CI^s)

$$=2\sum_i \left(\frac{y^f}{\bar{y}^f} - \frac{y^s}{\bar{y}^s}\right)(R^f - \frac{1}{2}) + 2\sum_i \left(\frac{y^s - \bar{y}^s}{\bar{y}^s}\right)(R^f - R^s) \qquad \text{(A4)}$$

where $\left(\frac{y^f}{\bar{y}^f} - \frac{y^s}{\bar{y}^s}\right)$ is the normalized obesity difference across two generations,
$\frac{y^s - \bar{y}^s}{\bar{y}^s}$ is the standardized son's obesity status, and
$(R^f - R^s)$ is the difference in intergenerational income ranking.

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