Relative Socioeconomic Status and Obesity Across the Life Course

by

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Abstract

Background: There is a marked social gradient with respect to obesity: lower social status is associated with greater body weight. The mechanisms underlying this phenomenon and how they operate across the life course are not well understood.

Methods: I performed a longitudinal analysis of data from the National Longitudinal Study of Adolescent to Adult Health (Add Health), a nationally representative sample of adolescents enrolled in grades 7-12 in the United States in 1994-1995 who have been followed into adulthood. There were 12,702 adolescents in the cohort with data available from adolescence and adulthood. I used sociodemographic and contextual data to create a measure of relative socioeconomic status (SES) by comparing individual SES to the average SES of his or her neighborhood in adolescence and adulthood. I calculated body mass index in adulthood using objective measures of height and weight. I then used a series of multiple regression models to test for associations between relative SES across the life course and BMI in adulthood. I test three models by which relative social disadvantage may influence body weight in later life: critical period, cumulation, and pathway models.

Results: When stratified by sex, there were no statistically significant relationships between early life or current relative SES and BMI for men. However, relative SES in both adolescence and early adulthood was significantly and inversely associated with BMI in adulthood among women.

Conclusions: The data provide some evidence for the pathways model and strong evidence for the cumulation model for women, suggesting that women, are sensitive to relative status differential in ways that may perpetuate disparities in obesity across the life course.
Systematic Review

Introduction

Socioeconomic status (SES) is a well-studied risk factor for a variety of health outcomes, with individuals of lower SES generally experiencing worse health. In particular, among developed nations, those with lower SES bear a disproportionate burden of obesity (Black & Macinko, 2010; Mujahid, Diez Roux, Borrell, & Nieto, 2005; Pardo-Crespo et al., 2013). Not surprisingly, this population also experiences disproportionately high rates of obesity-related health outcomes, including cardiovascular disease, dyslipidemia, and Type 2 diabetes mellitus (Mensah, 2005). Common indicators of SES for research focusing on individuals include income, wealth, educational attainment, welfare receipt, and occupation (Pudrovskà, Logan, & Richman, 2014). Researchers taking a broader community-level perspective on affluence may measure attributes of the neighborhood such as indices of affluence or deprivation, number of grocery stores, number of convenience stores, neighborhood walkability, and median household income. This line of research has yielded results of a similar theme: residents of low-poverty, more affluent neighborhoods have lower rates of obesity compared to their counterparts in more deprived neighborhoods (Powell, Wada, Krauss, & Wang, 2012).

The relationship between individual-level and neighborhood-level SES, to which we refer as “relative socioeconomic status”, is less well-studied. Interventions to promote healthy body weight would benefit from better characterization of this relationship. A better understanding of the interplay between individual SES and contextual neighborhood factors can aid public health practitioners and policy-makers in reducing disparities in obesity by better elucidating the conditions that create an obesogenic environment.
The goal of this systematic review was to identify and analyze the existing literature investigating how the relationship between individual SES and neighborhood SES may condition overweight or obesity.

Methods

*Search Strategy*

An electronic search of PubMed and Web of Science was conducted using the search terms in Table 1. Terms within each category (across rows) were separated by the Boolean operator “OR”, and categories were combined with the Boolean operator “AND”. Titles resulting from this query were assessed for relevance. Abstracts for relevant titles were retrieved and reviewed using predetermined inclusion and exclusion criteria. The corresponding full texts of those abstracts deemed relevant were reviewed using similar inclusion and exclusion criteria. The texts satisfying inclusion and exclusion criteria were included in the full analysis.

*Article Inclusion*

For inclusion in the full text analysis, articles must have measured individual-level and neighborhood-level socioeconomic status as well as some measure of body weight as an outcome (e.g. body mass index or dichotomous weight status variable). While studies investigating associations of individual socioeconomic position and neighborhood environment with body weight are relevant to this line of research, the present research question also required articles to address explicitly the relationship between individual-level and neighborhood-level socioeconomic status and its influence on body weight to be included in the full analysis. Failure to measure SES on both levels and assess the relationship between them as well as failure to measure body weight were grounds for exclusion from this systematic review. Papers were also excluded if they were unavailable in English or if the study was conducted in a developing
country. The prevalence of food insecurity is expected to alter the relationship between socioeconomic status and obesity. For this reason, our review was limited to developed nations, assuming comparable food supply and social dynamics.

Results

The literature search conducted in PubMed and Web of Science returned 919 titles. Of these, 105 were selected for abstract review; then 14 were selected for full text review. The reference section of each paper selected for full review was hand-searched for relevant titles. This yielded two relevant titles, and corresponding abstracts were reviewed for relevance but finally excluded from full review. Eleven full articles were excluded for reasons outlined below. The three remaining articles were selected for full analysis. See Figure 1 for a flow diagram of the search process.

Analysis

After review of full articles, 11 were excluded from the final analysis. This section outlines reasons for exclusion.

Wilkinson and Pickett present evidence linking income inequality to obesity at a societal level, drawing data from the 2003 Human Development Reports of the United Nations Development Program (Wilkinson & Pickett, 2007). The independent variable in this study is income inequality as measured by the ratio of the top quintile of income to the bottom quintile within a nation. Twenty-four nations were included in the analysis. Consideration of individual-level socioeconomic status was outside the scope of this study.

Chen and Meltzer explored the effects of relative social position on body weight, positing that cultural “norms” regarding body weight are shaped by observations of others in the
community. They test this hypothesis using data from the China Health and Nutrition Survey, selecting 190 communities across nine Chinese provinces. The provincial capital as well as a low-income city were selected within each province, and the remainder were selected at random. No sampling weights were available for this dataset, introducing a selection bias of unknown significance. Moreover, according to the authors, income limits food intake in rural China. This positive correlation between income and obesity is opposite the trend observed in Western developed societies, perhaps due to differing social norms and food supply. For these reasons, this study was excluded from full analysis.

The remainder of the excluded papers did not explicitly address the relationship between individual-level and neighborhood-level SES. For example, Black and Macinko conducted an analysis of New York City’s Community Health Survey data from 2003 to 2007. While they used appropriate measures of individual and neighborhood SES, the analysis involved simply including these and other covariates into a multivariate regression model and reporting the observed associations (Black & Macinko, 2010). Shrewsbury and Wardle conducted a systematic review of cross-sectional studies from 1990-2005 involving socioeconomic status and childhood adiposity. Studies met inclusion criteria for this review if they measured at least one indicator of SES, regardless of the level; these inclusion criteria are too broad to address the question of association between relative SES and obesity (Shrewsbury & Wardle, 2008). Pardo-Crespo and colleagues used data from telephone surveys among residents of Olmsted County, Minnesota, to assess the agreement between individual-level and area-level SES; they then used logistic regression models to determine which level was best predictive of risk of being overweight, but did not assess interaction between levels (Pardo-Crespo et al., 2013). Because
assessment of relationship between individual-level and neighborhood-level SES is critical in the study of relative SES, these papers were not selected for full analysis.

*Articles Included in Full Analysis*

The first article by Abeyta and colleagues was a cross-sectional analysis of data from the Colorado Behavioral Risk Factor Surveillance System (Abeyta, Tuit, Byers, & Sauaia, 2012). Characteristics of the study are outlined in Table 2. Individual SES was stratified into three discrete categories based on household income: low SES, medium SES, and high SES. The study used median household income at the county level to represent neighborhood-level SES; these data were also sorted into three categories: low, medium, and high. Six cardiovascular risk factors were assessed as outcomes, including body mass index calculated from self-reported height and weight. Obesity was defined as BMI ≥ 30 kg/m2. The study assessed the mediating influence of neighborhood SES on the association between individual SES and obesity by using multiple linear regression and including an interaction term involving community affluence and individual SES. They found that, among participants with high SES, there was a statistically significant (p<0.05) association between community affluence and obesity. Individuals belonging to medium and low SES categories demonstrated a trend of similar direction, but failed to meet criteria for significance.

The measurement strategy for this study involved grouping continuous data into categorical variables (e.g. sorting the continuous income variable into low, medium, and high SES). While this measurement approach would not likely affect the direction of the observed effect, the magnitude and confidence intervals may be inaccurate.
The obesity variable is based on self-reported data, which can be problematic because a significant proportion of overweight or obese adults under-estimate their body weight. In one study, approximately 42% of the non-athlete participants who were overweight or obese underestimated their body weight to such extent that they would fall into the “normal weight” category (Rote, Pineda, Wells, Lanou, & Wingert, 2015). Moreover, respondents in different SES groupings may under-report body weight at different rates, perhaps contributing to a differential measurement bias of unknown significance.

Other limitations of the study as described by the authors include that they analyzed data from only one state over only two years. While the sample may be representative of the state of Colorado, it is not readily generalizable to the United States or other Western developed nations. The lack of extended follow up may not adequately capture the time-dependent manifestations of poverty.

In the second article selected for full analysis, Li and colleagues conducted a prospective cohort study over the course of 10 years, drawing data from MigMed, a Swedish national database of population health data (Li, Memarian, Sundquist, Zoller, & Sundquist, 2014). Parental educational levels and family income were used to assess individual SES. Home addresses of participants were used to determine the neighborhood of residence. Neighborhood SES was measured with an index of neighborhood deprivation based on data regarding community education, income, unemployment, and proportion of residents receiving welfare. Incident diagnosis of childhood obesity in an outpatient clinic or hospital setting during the study period was the primary outcome variable. Logistic regression models testing for cross-level interactions were used to calculate the odds of being diagnosed with childhood obesity. They
found no statistically significant interactions between individual-level and neighborhood-level SES in the context of predicting likelihood of being diagnosed with childhood obesity.

The primary outcome of the study was diagnosis of childhood obesity in a clinical setting using objective measures of height and weight. As this outcome required interface with either an outpatient clinic or a hospital, differential access to health care may introduce a measurement bias. One advantage of the study is that it took place in Sweden, a nation with universal health care and relatively strong social welfare programs. Thus, affordability of care is likely not a barrier. However, other barriers such as transportation or a parent’s ability to leave work to take her child to clinic may selectively under-estimate the incidence of childhood obesity among lower-SES families.

Despite these limitations, the study benefited from a very large sample size which included the entire population of Sweden of ages 0-14 during the enrollment period. Another major strength of the study was the quality of the dataset, which had a very low proportion of missing data, contributing to better internal validity.

The final paper selected for full analysis was a cross-sectional survey of adults in New York City conducted by Rundle and colleagues (Rundle et al., 2008). Markers for individual SES included income and education, which were collected in the survey, along with objective measures of height and weight, from which the continuous outcome variable BMI was calculated. They used multi-level regression models with interaction terms and found a negative association between personal income and BMI among women in both richer and poorer neighborhoods; there was no association observed among men.

Participants were recruited in community settings such as health fairs and other community events. Those who volunteered at these recruitment events were enrolled in the
study. According to the authors, quotas used during the enrollment process were intended to create ethnic and socioeconomic diversity within the sample and to reflect the general sociodemographic characteristics of the population of New York City. However, given the study design, there was no way to account for the differential probabilities of participant selection. Recruiting from health fairs and community events may result in sampling only the most engaged and active members in the community; these attributes may not accurately reflect the entire community. Because of the recruitment methods used in the study, we cannot rule out the possibility of a significant selection bias, which poses a threat to its internal validity.

Discussion

The purpose of this systematic review was to identify and analyze literature regarding the association between relative socioeconomic status and obesity. To this end, I identified two relevant cross-sectional studies and one prospective cohort study which reported mixed results. Perhaps the strongest of the papers was the cohort study by Li and colleagues because of its longitudinal nature, large sample size, quality of the measures, and richness of the dataset regarding socioeconomic context. Despite the power of the study, they failed to detect an association between relative SES and a diagnosis of childhood obesity. Additionally, the duration of follow up was limited to 10 years. At the conclusion of the study, the oldest participants would be 24 years old. The effects of relative deprivation may take longer to manifest, perhaps not becoming evident until middle adulthood.

Abeyta and colleagues found a statistically significant association between community affluence and obesity only among individuals of high SES and a similar but non-significant relationship among low-SES and medium-SES subgroups (Abeyta et al., 2012). Rundle and
colleagues found an inverse relationship between personal income and BMI among women that was stronger in more affluent communities compared to those with less affluence (Rundle et al., 2008). Because of the cross-sectional design of the latter two studies, they were unable to provide evidence as to the direction of causality between relative SES and obesity.

Limitations

This review is subject to several important limitations, the first of which is limited human resources. Ideally, I would have reviewed all abstracts returned from the initial query for relevance. In addition, our search was limited to only two electronic databases; while these databases are extensive, they are not comprehensive, and there are perhaps relevant studies that are not included in either PubMed or Web of Science.

Another potential limitation is that the concept which I term “relative SES” may be expressed by other authors using different vocabulary that I did not capture using the search terms outlined in Table 1. Capturing all relevant studies may require using a more sensitive set of search terms and stringent inclusion and exclusion criteria to focus the selection process.

Conclusions

Overall, the evidence relevant to our study question is inconclusive. Broadly, residing in an affluent neighborhood appears to have a protective effect regardless of personal SES, perhaps operating through access to healthy foods and components of the built environment that facilitate physical activity. However, the health effects of an individual's position along the social hierarchy remain unclear.
The effects of poverty and deprivation are powerful, wide-reaching, and long-lasting. More specifically, the most significant morbidity and mortality related to obesity is typically seen among older adults. There is a paucity of research which follows the effects of relative SES on obesity into adulthood. The literature in this area of research would benefit from longitudinal studies with rich sociodemographic data beginning in childhood and continuing into adulthood. Such evidence would help to characterize the mechanisms of poverty in shaping health across the life course.
Tables and Figures

Table 1: PubMed and Web of Science search terms

<table>
<thead>
<tr>
<th>Table 1: PubMed and Web of Science search terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual-level terms</td>
</tr>
<tr>
<td>neighborhood, community</td>
</tr>
<tr>
<td>Neighborhood-level terms</td>
</tr>
<tr>
<td>neighborhood, neighbourhood, community</td>
</tr>
<tr>
<td>Socioeconomic status terms</td>
</tr>
<tr>
<td>deprivation, socioeconomic, SES (MeSH term), sociodemographic</td>
</tr>
<tr>
<td>Health Outcome terms</td>
</tr>
<tr>
<td>obesity, obesity (MeSH term), BMI, body mass index, body mass index (MeSH term), overweight, adiposity</td>
</tr>
</tbody>
</table>

Note: For the Web of Science search, MeSH terms were not utilized.
<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>Journal</th>
<th>Design</th>
<th>Population</th>
<th>Methods</th>
<th>Outcome Measure</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abeyta I, Tuitt N, Byers T, Sauaia A.</td>
<td>2012</td>
<td>Preventing Chronic Disease</td>
<td>Cross-sectional</td>
<td>20,739 residents of Colorado</td>
<td>Multiple linear regression with interaction term</td>
<td>6 CVD risk factors, including BMI, calculated from self-reported height and weight</td>
<td>Among low-SES individuals, living in medium or high affluence communities is associated with lower risk of obesity</td>
</tr>
<tr>
<td>Li X, Memarian E, Sundquist J, Zoller B, Sundquist K.</td>
<td>2014</td>
<td>Obesity Facts</td>
<td>Prospective cohort</td>
<td>948,062 Swedish children aged 0-14 years between the years 2000 and 2010</td>
<td>Multilevel logistic regression models testing for cross-level interaction s</td>
<td>Diagnosis of childhood obesity in out-patient clinic or hospital</td>
<td>No significant interactions found between individual-level and neighborhood-level SES regarding risk of being diagnosed with childhood obesity</td>
</tr>
<tr>
<td>Rundle A, Field S, Park Y, Freeman L, Weiss C, Neckerman K.</td>
<td>2008</td>
<td>Social Science &amp; Medicine</td>
<td>Cross-sectional</td>
<td>13,102 adult residents of New York City</td>
<td>Multiple linear regression models with interaction term</td>
<td>BMI, calculated from objective measures of height and weight</td>
<td>Negative association between personal income and BMI among women in both richer and poorer neighborhoods; no association observed among men</td>
</tr>
</tbody>
</table>
Figure 1: Flow Diagram of Review Process

Define Search Terms (see Table 1)

Conduct Search in PubMed and Web of Science

Title Review (n=919)

Abstract Review (n=105)

Full Text Review (n=14)

Full Review Analysis (n=3)

Titles were excluded for the following:
- Not addressing individual-level SES (n=176)
- Not addressing obesity or overweight as an outcome (n=455)
- Not addressing socioeconomic conditions (n=165)
- Not available in English language (n=18)

Abstracts were excluded for the following:
- Not addressing Individual-level SES (n=18)
- Not addressing neighborhood-level SES (n=50)
- Not addressing obesity or overweight as an outcome (n=10)
- Not addressing socioeconomic conditions (n=5)
- No abstract available (n=2)
- Not addressing interaction between individual and neighborhood SES (n=6)

Hand search of references of Full Review texts (n=2)
References


economic contextual factors. *Social Science & Medicine, 75*(3), 469-476.
doi:10.1016/j.socscimed.2012.03.019


Relative Socioeconomic Status and Obesity Across the Life Course

Introduction

An estimated one-third of adults in the United States are obese, a proportion that has grown over the past several decades. In addition, nearly one-fifth of youths aged 2 to 19 years are obese, increasing the risk of serious and chronic health problems. Obesity, defined as having a body mass index (BMI) of 30 kg/m² or greater among adults or a BMI for Age greater than the 85th Percentile among children (Ogden, Carroll, Kit, & Flegal, 2014), is strongly related to heart disease, type 2 diabetes mellitus, stroke, and some forms of cancer. As this cluster of diseases represents a significant proportion of preventable morbidity and mortality, it is an important target for public health intervention. More specifically, there are persistent and marked disparities in obesity based on socioeconomic status (SES). Low SES groups have a disproportionately high prevalence of obesity (Mensah, 2005; Wang & Beydoun, 2007).

Existing literature has consistently shown associations between SES and disease (Link & Phelan, 1995; Phelan, Link, & Tehranifar, 2010). In the literature focusing on obesity, several distinct themes emerge based on the geographical site of the study. A study of Singaporean Chinese men and women found that low childhood SES decreases the likelihood of obesity. However, lower SES in adulthood increased the likelihood of obesity among women (Malhotra, Malhotra, Chan, & Østbye, 2013). In contrast, several Western studies have shown another distinct theme. Studies in Spain and Sweden have found that socioeconomic disadvantage in adulthood is an important predictor for high BMI (Padyab & Norberg, 2014; Regidor, Gutiérrez-Fisac, Banegas, López-García, & Rodríguez-Artalejo, 2004). Similarly, analyses of the Wisconsin Longitudinal Study show that socioeconomic disadvantage in childhood is significantly associated with higher risk of obesity in adulthood after controlling for known
mediating variables such as dietary and exercise habits; this relationship is especially strong for women (T. Pudovska, Logan, & Richman, 2014; T. Pudovska, Reither, Logan, & Sherman-Wilkins, 2014).

In their seminal paper, Link and Phelan argued that social conditions such as low SES are “fundamental causes” of disease. Social conditions are “fundamental” in that they can result in disease through many various mechanisms such that even if mediating mechanisms change, there remains a significant association between social factors and disease (Link & Phelan, 1995). This hypothesis is consistent with other studies of SES and health: after adjusting for proximate risk factors (e.g. systolic blood pressure, weekly exercise, dietary saturated fats, use of statin drug, or family history of heart disease), there remains an association between SES and health outcomes (Franks, Winters, Tancredi, & Fiscella, 2011; Muennig, Sohler, & Mahato, 2007).

**Socioeconomic Status and Health: Linking Biography with Physiology**

One mechanism by which lower SES can lead to obesity is through lack of access to affordable, nutritious foods. Less expensive foods are often calorie-dense and nutrient poor, contributing to excess total caloric intake. If healthful fruits, vegetables, and other nutrient-rich foods are available, the cost is often prohibitive. Moreover, lower income communities often have less access to safe sidewalks and physical activity facilities, promoting a sedentary lifestyle (Wang & Beydoun, 2007). An abundance of relatively inexpensive high-calorie foods and limited opportunity for physical activity together produce an obesogenic environment that disproportionately affects lower SES individuals.

Another hypothesized mechanism by which SES influences obesity implicates the hypothalamic-pituitary-adrenal (HPA) axis and the chronic stress of living in a low-SES
environment. One function of the HPA axis is to regulate cortisol, a glucocorticoid hormone released by the adrenal glands. High levels of cortisol are associated with high levels of stress. While the body’s acute stress response can be adaptive and beneficial for survival, research suggests that the long-term effects of chronic stress are maladaptive. In the setting of chronically high levels of glucocorticoids, researchers have observed greater salience of pleasurable activities, including ingesting “comfort foods” such as those high in sugars and fats. Additionally, high chronic glucocorticoids promote abdominal fat deposition (Dallman et al., 2003).

In addition to the HPA axis, other pathways have been shown to link daily experiences with biology in ways that can influence health. The function of the autonomic nervous system, responsible for regulating epinephrine and norepinephrine as well the “fight or flight” response, is shaped by experiences, and its dysfunction can have untoward effects on health. Similarly, stress can have untoward effects on the development of the prefrontal cortex, a part of the brain that is crucial for attention and other higher-order executive functions (Hertzman & Boyce, 2010).

Relative Socioeconomic Status

Social evaluative threats, or situations in which an individual’s social status or self-esteem is threatened, are potent inducers of salivary cortisol, suggesting that they are also potent stressors. Where along the social hierarchy others regard an individual’s position greatly informs his or her self-esteem and subjective social status. Higher status is often associated with greater ability, greater success, greater sense of control of one’s life, and superiority (Wilkinson, 2009). Thus, lower SES individuals have less of a buffer against social evaluative threat and subsequent chronic stress.
Literature in this area has found mixed evidence of an association between subjective social status and health outcomes that is moderated by gender. One study found a significant association between higher subjective social status and lower odds of being overweight or obese among Japanese and South Korean women (Frerichs, Huang, & Chen, 2014). Another used data from the English Longitudinal Study of Ageing and found a significant inverse association between subjective social status and central obesity (as measured by waist circumference) for women. However, the significance diminished after adjusting for education, occupational class, and wealth (Demakakos, Nazroo, Breeze, & Marmot, 2008).

The health effects of being in a subordinate position along the social hierarchy are evident even in early childhood. Among children aged 3 to 5 years, social subordination observed in childhood classroom interactions was associated with greater response to stress with respect to cardiovascular and autonomic nervous systems. Additionally, among these children of relative low social status, there was a high and disparate rate of chronic disease compared to their higher-status classmates, even after controlling for socioeconomic factors at the household level (Hertzman & Boyce, 2010).

These findings suggest that absolute socioeconomic status, while an important factor in predicting disease, is not sufficient. The social hierarchy by which individuals are judged is necessarily context-dependent. In other words, the same individual may be high on the social ladder in a poor community, but quite low in the social hierarchy in a very affluent community. Research on relative SES provides inconclusive evidence, with some studies suggesting a consistent inverse relationship between individual SES and BMI among women that is stronger in more affluent neighborhoods compared to those with less affluence (Rundle et al., 2008). To my knowledge, there is a paucity of research on the relationship between an objective measure of
relative SES and obesity from a life course perspective. The present research proposes relative SES as a distinct and salient risk factor contributing to obesity and operating across the life course.

**Life Course Perspective**

Life course research emphasizes sequences of statuses and roles across the life span (The craft of life course research 2009). These statuses can be conceptualized as what O’Rand terms life course capital, defined as “multiple stocks of resources that can be converted and exchanged to meet human needs and wants”. Life course capital exists in multiple interconnected forms, such as personal capital, psychophysical capital (including mental and physical health), social capital, and others. For example, deterioration in health affects one’s earning potential and financial status, which can limit access to health care, in turn affecting health. It is the complex interactions among these multiple domains that condition the accumulation, maintenance, or depletion of life course capital (O'Rand, 2001; O’Rand, 2006). In this study, I empirically test three mechanisms by which relative social disadvantage, as a measure of life course capital, may influence outcomes in later life: critical period, cumulation, and pathway models.

**Critical Period Model**

The critical period model posits that exposures early in an individual’s life have long-lasting and potentially irreversible sequelae later in life that cannot be explained by exposures later in life (Ben-Shlomo & Kuh, 2002; T. Pudrovksa & Anikputa, 2014). Early exposures create strong path-dependence irrespective of later life events. A clear example of this phenomenon is that preterm birth is associated with an increased burden of pulmonary and cardiovascular disease in
later life despite beneficial exposures in later life (Roos et al., 2013). In terms of the life course perspective, early life course capital is the only capital that matters. The strongest support for this model would be evidence of a significant association of early life exposures on later life outcomes and no increased risk contributed by later life exposures. Thus, drawing from the critical period model, I hypothesize that:

H1: There is a significant association between relative SES in adolescence and BMI and that relationship does not change even when relative SES in adulthood is taken into account.

Accumulation (Cumulation) Model

Cumulation, or the concept of cumulative advantage was first introduced to explain differential successes among scientific careers. Termed the Matthew Effect by Merton, it is defined as the “accruing of greater increments of recognition for particular scientific contributions to scientists of considerable repute and the withholding of such recognition from scientists who have not yet made their mark.” (Merton, 1968) The scope of this phenomenon has expanded beyond that of studying scientific careers. Increasingly, scholars are applying the concept of cumulative advantage to study areas such as crime, education, racism, and health (DiPrete & Eirich, 2006; Willson, Shuey, & Elder Jr, 2007).

More broadly, cumulation posits that the relative advantage of one group over another is magnified across the life course, captured by the colloquialisms “the rich get richer” and “the poor get poorer.” Another way to conceptualize cumulation is those with greater life course capital are better able to leverage these resources to protect and accumulate more capital. By contrast, those of lower life course capital may be less able to mitigate forces that threaten to
deplete their capital. In this way, disparities between those of higher capital and lower capital grow over time. According to the cumulation model, exposures early in life accumulate over the life course and exert compounding effects on later life outcomes. Drawing from the cumulation model, I hypothesize that:

H2: BMI is significantly associated with both early life relative SES and relative SES in adulthood, evincing additive effects of relative SES over the life course.

Pathways Model

The pathways model hypothesizes that exposures early in life condition the development of outcomes later in life by shaping intermediate exposures and experiences. Thus, life course capital early in life increases the opportunities to gain and access capital later in life. These indirect effects are mediated by later exposures (T. Pudrovska & Anikputa, 2014). Operationally, evidence for this model would be demonstration of a strong association between an early life exposure and an outcome that is attenuated by the addition of later life outcomes into the model. According to this pathways model, I hypothesize that:

H3: There is a significant association between relative SES in adolescence and adulthood BMI that is mediated by the addition of later life relative SES to the model.

Methods

The National Longitudinal Study of Adolescent to Adult Health (Add Health) is a longitudinal study of a nationally representative sample of adolescents enrolled in 7-12 grades in
the United States 1994-1995. The sample was drawn from 132 schools in 80 neighborhoods. In each community, a high school was selected as well as one of its feeder schools, most commonly a middle school. The participants have been followed into adulthood with four interviews which took place in the participants’ homes.

Contextual data regarding the participants’ neighborhoods were drawn from census data. The use of post stratification sampling weights ensured that the respondents were representative of students in grades 7-12 in the United States in 1994-1995 (Harris, 2013). The present study uses individual and contextual data from Wave I (collected during adolescence) and Wave IV (collected in adulthood).

Measures

Relative SES

Testing my hypotheses requires the use of equally valid measures of SES in adolescence and in adulthood. At Wave I, the primary earners contributing to household income were likely the parent(s), who were presumably further along in their career than the respondent in Wave IV, who was likely the main contributor to Wave IV household income. Thus, household income does not reliably measure SES at Wave I and Wave IV with comparable validity.

I therefore used data regarding parental educational attainment during the in-home interviews in Wave I to construct a measure of the respondent’s SES in adolescence. I created a categorical variable of 1 (less than a high school education), 2 (a high school diploma but no further degrees), and 3 (college degree or greater). Personal educational attainment reported in Wave IV served as a measure of SES in adulthood. Using contextual data at the census tract level regarding the proportion of adults in the neighborhood with less than a high school
education, a high school diploma, or a college degree or greater, I then created a weighted variable reflecting the average educational attainment of adults aged 25 years or more in the neighborhood, again on the same scale of 1-3. To accomplish this, I multiplied the proportion of adults with less than a high school diploma by 1; the proportion of those with only a high school diploma by 2; and the proportion of adults with a college degree or greater by 3. I then averaged these weighted proportions to calculate the average level of neighborhood educational attainment on a scale of 1 to 3.

In this manner, I gathered measures of individual-level SES in Wave I (parental educational attainment) and Wave IV (personal educational attainment). I also gathered measures of Wave I and Wave IV neighborhood-level SES, represented by the neighborhood average educational attainment values. The quotient of parental education and the average neighborhood education reflected the respondent’s SES in adolescence relative to his or her neighborhood. Similarly, the quotient of Wave IV personal educational attainment and the average neighborhood educational level represented relative SES in adulthood. Therefore, a relative SES value of 1.0 would indicate that the respondent’s SES is exactly average for his or her neighborhood; a value greater than 1.0 indicates that an individual is of a higher SES compared to the average for his or her neighborhood. For each of Wave I and Wave IV, the following equation summarizes the construction of the relative SES variable:

\[
\text{Relative SES} = \frac{\text{Individual SES}}{\text{Neighborhood SES}}
\]
**Body Mass Index**

Figure 1: Conceptual Models

Height and weight data collected at Wave IV were used to calculate the respondent’s body mass index (BMI), measured in kg/m$^2$.

**Statistical Analysis**

All analyses were conducted using Stata software, version 13.1 (Stata Corp, College Station, Texas). Sampling weights were used to account for the sampling strategy used in the Add Health study design. A series of multivariate regression models were created, all of which included BMI at Wave IV as the continuous dependent variable. All models were stratified by sex and adjusted for age, self-reported race/ethnicity, and immigration history, the latter of which may constrain choice in relocating into or out from neighborhoods. The conceptual models forming the basis of this analysis are depicted in Figure 1. First, BMI was regressed on Wave I relative SES to assess the relationship between relative status in adolescence and adulthood BMI. Second, BMI was regressed on Wave IV relative SES, evaluating the association between adulthood relative status and BMI. Lastly, BMI was regressed on Wave I relative SES and Wave IV relative SES to assess the degree to which adulthood relative SES mediates the effects of relative SES in adolescence (Baron & Kenny, 1986).
Results

Table 1 shows demographic characteristics for the study participants who were followed into Wave IV. The average age at Wave IV was 28 years old for men and women. Men and women had similar distributions with respect to race/ethnicity. The average neighborhood educational attainment was comparable between men and women and stable from Wave I to Wave IV. Similarly, individual level educational attainment (parental education at Wave I and personal education at Wave IV) was similar within each wave and stable across waves. Average Wave I BMI data fall within “normal” weight (18.5-24.99 kg/m²). Notably, though body mass
index measurements are comparable at Wave IV, the averages for both men and women fall within the “overweight” or “pre-obese” range (25-29.99 kg/m²).

Results of the multivariate regression analyses are shown in Table 2. A negative coefficient indicates that a higher relative socioeconomic status is associated with a lower body mass index. Overall, there is a statistically significant relationship between BMI and early life relative SES (shown in Total, model I) as well as current relative SES (Total, model II). The combined model (Total, model III) shows a significant relationship with current relative SES and a partially attenuated relationship with early life relative SES. When stratified by sex, there are no statistically significant relationships between early life or current relative SES and BMI for men. However, for women, there is a strong and significant negative correlation with early life relative SES and current relative SES. With both time points in the model (Women, model III), the effect of early life relative SES is partially attenuated. However, there remains a strong and statistically significant reduction in BMI in adulthood associated with higher relative SES in both adolescence and adulthood.

Discussion

Overall, these data suggest mixed evidence of pathway and accumulation models since the effect of early life relative SES was attenuated when current relative SES entered the model. After stratifying by sex, there was no statistically significant association between relative socioeconomic status and body mass index for men. By contrast, there are strong and statistically significant relationships in all three models for women. The partial attenuation of the coefficient for early life relative SES from model I to model III suggests that some, but not all, of the effect of early life relative SES is mediated by relative SES in adulthood. This finding
is consistent with the pathway model. However, the association for relative SES at each of the
time points remains significant in the third model, indicating a concurrent cumulative process.
Thus, the data provide some evidence for the pathways model and strong evidence for the
cumulation model for women. A gendered difference in vulnerability to low relative SES is
consistent with existing literature. This research builds upon the existing body of literature by
incorporating a life course perspective and empirically exploring life course mechanisms linking
relative SES and BMI. The longitudinal nature of this data, extending from adolescence into
adulthood, is also a valuable addition to the relative SES literature. The transition from
adolescence to adulthood is an important period for development of healthy behaviors. To our
knowledge, there are no other longitudinal studies that capture relative SES across this critical
stage of life and follow participants this far into adulthood.

Limitations

As with any observational study, this study is subject to selection bias in several
important ways. The literature surrounding cumulative advantage and health postulates that
inequalities over the life course are bounded by age due to differential rates of attrition and
mortality among those with greater disadvantage. This differential can obscure the effects of
cumulation, creating the illusion of an age-as-leveler process and converging trajectories (T.
Pudrovska, 2014; Willson et al., 2007). Bias due to mortality is not of great concern in this
sample of young adults; however, of those who were eligible to participate in Wave IV,
approximately 9.1% were unwilling. Despite use of sampling weights to adjust for the sampling
strategy used in Add Health, there are unobserved factors that may have contributed to
individuals’ unwillingness to participate and obscured the observed relationship between relative SES and body weight.

Secondly, some adolescents were obese at Wave I, and there is a strong association between obesity at Wave I and obesity at Wave IV. The present study design does not account for unobservable factors that may affect selection into obesity at Wave I. Statistical adjustment for Wave I BMI, in essence creating a change model, would greatly increase the specificity of the results. However, this adjustment would come at the expense of sensitivity. Despite this limitation, the present findings are meaningful, as studying sustained high body weight across the transition from adolescence into adulthood is as important to population health as the development of high body weight over the same period. Further characterization of mechanisms by which relative SES influences BMI may identify potential targets for intervention efforts.

Though relative SES may be distinct from absolute SES conceptually, it is difficult to tease apart empirically with this design. This research suggests the salience of relative SES across the life course in predicting obesity. However, overall risk of obesity is likely shaped by a balance between absolute and relative SES and may be different in other contexts. Additional comparative studies in other countries may help to illuminate the risk attributable to absolute SES versus that attributable to relative SES.

Implications

This research suggests that individuals, especially women, are sensitive to status differences at multiple points throughout the life course through mechanisms that perpetuate health disparities. Policies aiming to reduce disparities could take advantage of these findings by targeting adolescent girls for obesity prevention efforts as they transition to adulthood. Although
early life relative deprivation is a predictor for obesity later in life, policies should not discount the salience of relative status in adulthood as well. This study shapes our understanding of social inequalities as they affect health. Education regarding healthy patterns of eating and physical activity may not be sufficient to reduce disparities in obesity. Rather, interventions that address unique sensitivity to status differentials may meet with greater success. As long as structural inequality remains, existing interventions may benefit individuals, but sustainable benefit at the population level may be out of reach.
Table 1. Demographic Characteristics of Study Participants

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Males (n=5993)</th>
<th>Females (n=6709)</th>
<th>Total (n=12702)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age at Wave 4 (SE)</strong></td>
<td>28.4 (0.1)</td>
<td>28.2 (0.1)</td>
<td>28.3 (0.1)</td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
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<tr>
<td>Non-Hispanic White</td>
<td>4051 (67.6)</td>
<td>4522 (67.4)</td>
<td>8573 (67.5)</td>
</tr>
<tr>
<td>Non-Hispanic Black</td>
<td>935 (15.6)</td>
<td>1093 (16.3)</td>
<td>2028 (15.9)</td>
</tr>
<tr>
<td>Non-Hispanic Asian</td>
<td>204 (3.4)</td>
<td>208 (3.1)</td>
<td>412 (3.2)</td>
</tr>
<tr>
<td>Non-Hispanic Other/Native American</td>
<td>84 (1.4)</td>
<td>74 (1.1)</td>
<td>158 (1.2)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>719 (12.0)</td>
<td>812 (12.1)</td>
<td>1531 (12.0)</td>
</tr>
<tr>
<td>Neighborhood Characteristics</td>
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</tr>
<tr>
<td>Wave I</td>
<td>Avg. Education, Age 25+ (1-3)</td>
<td>2.0 (&lt;0.1)</td>
<td>2.0 (&lt;0.1)</td>
</tr>
<tr>
<td>Wave IV</td>
<td>Avg. Education, Age 25+ (1-3)</td>
<td>2.1 (&lt;0.1)</td>
<td>2.1 (&lt;0.1)</td>
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<tr>
<td><strong>Wave I measures</strong></td>
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<tr>
<td>Parental education (1-3)</td>
<td>2.1 (&lt;0.1)</td>
<td>2.0 (&lt;0.1)</td>
<td>2.1 (&lt;0.1)</td>
</tr>
<tr>
<td>Relative SES (education) (SE)</td>
<td>1.06 (0.01)</td>
<td>1.04 (0.01)</td>
<td>1.05 (0.01)</td>
</tr>
<tr>
<td>BMI (SE)</td>
<td>22.7 (0.1)</td>
<td>22.3 (0.1)</td>
<td>22.5 (0.1)</td>
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<tr>
<td><strong>Wave IV measures</strong></td>
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</tr>
<tr>
<td>Personal education (1-3)</td>
<td>2.2 (&lt;0.1)</td>
<td>2.3 (&lt;0.1)</td>
<td>2.2 (&lt;0.1)</td>
</tr>
<tr>
<td>Relative SES (education) (SE)</td>
<td>1.04 (0.01)</td>
<td>1.08 (0.01)</td>
<td>1.06 (0.01)</td>
</tr>
<tr>
<td>BMI (SE)</td>
<td>29.0 (0.1)</td>
<td>29.2 (0.2)</td>
<td>29.1 (0.1)</td>
</tr>
</tbody>
</table>
Table 2: Associations between Adolescent and Adulthood Relative SES and Adulthood BMI, β coefficients (SE)

<table>
<thead>
<tr>
<th>BMI</th>
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<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
<td>III</td>
<td>I</td>
<td>II</td>
<td>III</td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>Adolescent relative SES</td>
<td>-0.03</td>
<td>0.11</td>
<td>-1.73***</td>
<td>-1.40**</td>
<td>-0.88**</td>
<td>-0.66†</td>
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</tr>
<tr>
<td>(0.47)</td>
<td>0.49</td>
<td>0.46</td>
<td>0.50</td>
<td>0.33</td>
<td>0.34</td>
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<tr>
<td>Adulthood relative SES</td>
<td>-0.47</td>
<td>-0.61</td>
<td>-1.88***</td>
<td>-1.71**</td>
<td>-1.10**</td>
<td>-1.13*</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>0.40</td>
<td>0.42</td>
<td>0.45</td>
<td>0.52</td>
<td>0.32</td>
<td>0.37</td>
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</tbody>
</table>

***p<0.001; **p<0.01; *p<0.05; †p<0.1

Note: All models adjusted for age, race/ethnicity, and immigration history


Franks, P., Winters, P. C., Tancredi, D. J., & Fiscella, K. A. (2011). Do changes in traditional coronary heart disease risk factors over time explain the association between socio-


