SSM - Population Health 24 (2023) 101556

Contents lists available at ScienceDirect

SSM - Population Health

journal homepage: www.elsevier.com/locate/ssmph

Early life socioeconomic position contributes to adult obesity independent of adult socioeconomic factors: Findings from the sister study cohort

Jennifer M.P. Woo [a,*], Deborah B. Bookwalter [b], Geannette Y. Green [b], Dale P. Sandler [a,**]

[a] Epidemiology Branch, National Institute of Environmental Health Sciences, 111 T.W. Alexander Dr., Research Triangle Park, NC, 27709, USA
[b] Westat, Inc., 1009 Slater Rd # 110, Durham, NC, 27703, USA

A B S T R A C T

Low socioeconomic position (SEP) has been associated with obesity within life stages; however, life course SEP may also alter downstream obesity risk. Research is needed to understand the impact of childhood SEP, independent of adult SEP, as well as SEP trajectories over the life course on adult obesity risk. We use data from the Sister Study, a prospective U.S. cohort of women aged 35–74 years (N = 50,884; enrollment: 2003–2009). Relative risks (RR) for adult obesity associated with childhood SEP (latent variable) and five latent life course SEP profiles were estimated in overall and race and ethnicity-stratified log binomial regression models. We estimated the direct effect of childhood SEP on adult obesity and mediation by adult SEP. Lower childhood SEP was associated with greater obesity risk (RR = 1.16, 95% CI: 1.15–1.17). In stratified models, RRs were elevated across groups though lower for Black and Hispanic/Latina participants, despite greater prevalence of obesity among Black participants. The direct effect of childhood SEP on adult obesity persisted in mediation models independent of adult SEP (RR = 1.10, 95% CI: 1.08–1.12) with adult SEP mediating approximately 40% of the total effect of childhood SEP on adult obesity. Furthermore, adult obesity risk was elevated for all life course SEP profiles compared to persistent high advantage. Life course SEP profiles indicating greater advantage in adulthood than childhood were not associated with reduced adult obesity risk among those experiencing less than high advantage in childhood. In conclusion, lower childhood SEP, independent of adult SEP, may be an important risk factor for adult obesity.

Author contributions

Jennifer Woo: Formal analyses, investigation, methodology, visualization, writing-original draft and review and editing.

Deborah Bookwalter: Conceptualization, methodology, validation, writing-review and editing.

Geannette Green: Conceptualization, writing-review and editing.

Dale Sandler: Conceptualization, supervision, methodology, writing-review and editing.

1. Introduction

Overweight and obesity is a prevalent health concern that affects approximately three quarters (74%) of U.S. adults with over 40% of these classified as obese (Fryar et al., 2020). Growing evidence suggests that structural and institutional barriers, such as unequal access to healthy food options and quality healthcare as well as structural racism and residential segregation contribute to the racial and ethnic- and socioeconomic position (SEP)-related patterns of obesity in the United States (Cooksey-Stowers et al., 2017; Cozier et al., 2014; Kershaw et al., 2013). Non-Hispanic Black women bear the greatest burden of prevalent obesity in the U.S. (57%), followed by Hispanic/Latina (46%) and Non-Hispanic white (36%) women (Ogden et al., 2017). Obesity is a recognized risk factor of multiple chronic health conditions, including diabetes, hypertension, high cholesterol, and heart disease, contributing to increased morbidity and mortality (National Heart Lung and Blood Institute, 2013).

Life course theory posits that specific exposures during sensitive periods, such as childhood and adolescence, or cumulative exposures over the life course may differentially contribute to downstream health effects (Ben-Shlomo & Kuh, 2002). Childhood and adolescence represent potentially sensitive periods in the etiology of adult obesity related to biological and hormonal changes associated with puberty and the development of fundamental health behaviors due to surrounding social and societal exposures. Multiple studies have established that obesity is a multi-faceted problem with possible correlates of increased body mass index emerging during childhood and contributing to negative health consequences later in life (James et al., 2006; Power & Parsons, 2000).

* Corresponding author. 111 T.W. Alexander Drive, MD A3-05, P.O. Box 12233; Research Triangle Park, NC, 27709, USA.
** Corresponding author. 111 T.W. Alexander Drive, MD A3-05, P.O. Box 12233, Research Triangle Park, NC, 27709, USA.
E-mail addresses: jennifer.woo@nih.gov (J.M.P. Woo), deborahbookwalter@westat.com (D.B. Bookwalter), gnette.green@gmail.com (G.Y. Green), Sandler@niehs.nih.gov (D.P. Sandler).

https://doi.org/10.1016/j.ssmph.2023.101556
Received 20 July 2023; Received in revised form 30 October 2023; Accepted 4 November 2023
Available online 10 November 2023

Moreover, poor childhood diet and food deprivation, coupled with low SEP and associated cultural, environmental, and social factors may contribute to additional weight gain over the life course by inhibiting the development of positive food habits and promoting continued food insecurity (James et al., 2006).

1.1. Measurement of SEP

Socioeconomic position is a multi-dimensional construct that encompasses the social and economic factors that dictate the positions individuals or groups are perceived to hold within the larger societal structure (Galobardes et al., 2006). Previous studies, including a review by Senese et al. (2009), have reported on the inverse association between single measures of childhood SEP (e.g., parental education, childhood household income, etc.) and obesity among women overall (Baltrus et al., 2005; Newton et al., 2017; Power et al., 2005; Trotter et al., 2010) with variation in the magnitude of effects observed across racial and ethnic groups (James et al., 2006; Kershaw et al., 2013; Sullivan et al., 2014). Similarly, in other fields where SEP is commonly studied (e.g., psychology), the measurement of SEP is also highly varied; a recent review of over 150 psychology-related articles that evaluated SEP reported over 50% of studies used one or more single indicators to measure SEP (Antonoplis, 2023). Despite the noted benefits of using single or restricted indicators of SEP, including model parsimony or identifying relevant mechanisms linking aspects of SEP to specific health outcomes, there is no single indicator that best represents SEP for all studies nor do they represent SEP as a singular construct (Galobardes et al., 2006). Studies that aim to describe the effects of SEP when only using single indicators tend to capture the effect of singular dimensions of SEP and fail to capture how different dimensions of SEP may interact to comprise the construct of SEP as whole.

Prior research has noted the limitations of using single variables to represent SEP as they may not capture the full experience of childhood SEP and its subsequent influence on downstream health outcomes, such as adult obesity (Senese et al., 2009). The use of latent variables can help to overcome some of this variability by better characterizing the underlying construct of childhood SEP, including potentially unmeasured factors that can influence childhood SEP, such as internalized systemic aggressions and associated psychosocial stress. Although work on accepted measures of neighborhood SEP and area deprivation have been more readily adopted, such as the neighborhood deprivation index (Kind & Buckingham, 2018), data reduction methods to assess individual SEP as a multi-dimensional latent construct have been less standardized.

In addition to being multi-dimensional, SEP can change over the life course, but few studies have assessed the role of SEP trajectory or the role of childhood SEP, independent of adult SEP, on adult obesity (M. Li et al., 2018; Scharoun-Lee et al., 2009). The social mobility model posits that the sequence of SEP over the life course has greater health implication than SEP at a single time point (Cohen et al., 2010). Previous studies have demonstrated attenuation of effect estimates of the association between childhood SEP and adult obesity after adjusting for adult SEP and obesity risk factors (e.g., diet, smoking status, and alcohol use) (Senese et al., 2009), but the direct impact of childhood SEP on adult obesity, independent of adult SEP remains unclear. Identifying sensitive windows of susceptibility can help to elucidate periods when obesity prevention interventions may have the greatest impact.

A final consideration when studying SEP pertains to changes in how indicators have historically contributed to the measure of SEP and how this may differentially impact estimates of disease risk, which is particularly important for cohorts with participants with a wide age distribution. For example, in age-adjusted studies among females born before and after 1950, the inverse association between childhood SEP and adult obesity was more common in populations born after 1950 (Senese et al., 2009). This is consistent with cohort effects of increased age-adjusted obesity observed among those born after 1955 in the US (Reither et al., 2009; Robinson et al., 2013). These effect differences coincide with changes in the political and economic landscapes following World War II, the shift in the dynamics between educational attainment and SEP, and the steady growth of obesogenic environments (e.g., food outlets, sedentary lifestyles, etc.). As a result, cohort effects in obesity risk may persist after adjusting for age.

1.2. Rationale and study objectives

To address the limitations of using singular indicators of SEP in the study of childhood SEP and SEP trajectory over the life course, this study uses confirmatory factor analysis, a data reduction approach, to estimate structural models for the measurement of SEP using seven previously studied indicators of SEP. The primary aims of this study are 1) to investigate whether childhood SEP predicts obesity in adulthood independent of adult SEP and 2) to assess how life course SEP trajectory affects adult obesity risk among a large ethnically diverse sample of women. Based on existing literature, we hypothesize that participants with low SEP in childhood are more likely to present with adult obesity; furthermore, we anticipate that a portion of this association exists independent of adult SEP, which may be attributable to normalized lifestyle behaviors, epigenetic modification, or priming of hormonal milieus that may predispose individuals to increased weight gain later in life.

2. Methods

2.1. Study population

This study uses baseline data from the Sister Study, a prospective study of environmental and genetic risk factors for breast cancer and other conditions. The cohort consists of 50,884 self-identified women from the United States, including Puerto Rico, who were 35–74 years of age at enrollment (2003–2009). Participants had at least one sister (full or half) diagnosed with breast cancer, but no breast cancer diagnosis themselves at baseline (Sandler et al., 2017). Details of the study design and enrollment process have been described (D'Aloisio et al., 2010). The Sister Study was approved by the Institutional Review Board of the National Institutes of Health. All participants provided written consent. We use data from Sister Study Data Release 9.0.

Baseline visits consisted of computer-assisted telephone interviews and self-administered questionnaires, which assessed demographics, medical history, and possible risk factors for breast cancer and other health conditions along with childhood exposures and experiences (D'Aloisio et al., 2010). Furthermore, participants could consult with their parents and relatives to increase accuracy of childhood-related questionnaire responses (D'Aloisio et al., 2010).

Our analysis included 50,849 enrolled participants. We excluded participants who were missing baseline anthropometric data ($n = 20$), all measures of childhood SEP ($n = 5$), race and ethnicity information ($n = 15$), or all adult SEP variables ($n = 11$, in mediation analyses only), as well as those participants who withdrew from the study ($n = 3$); missingness was less than 0.05% for all remaining variables.

2.2. Obesity – outcome of interest

Following enrollment, study personnel measured participants' height and weight following standardized study protocols at in person home visits (D'Aloisio et al., 2010). A continuous measure of body mass index (BMI) was calculated from baseline anthropometric data (BMI = weight (kg)/height squared (m^2)). Participant weight status was then categorized using Centers for Disease Control and Prevention (CDC) BMI cutoffs (underweight—BMI <18.5 kg/m^2, normal or healthy weight—BMI 18.5 to < 25 kg/m^2, overweight—BMI 25 to < 30 kg/m^2, obese-BMI ≥ 30 kg/m^2) (National Heart, Lung, and Blood Institute Obesity Education Initiative Expert Panel on the Identification, Evaluation, and Treatment of Obesity in Adults, 1998).

2.3. Early life and life course socioeconomic position – exposure of interest

Data on childhood SEP included self-reported mother's highest educational attainment by age 13 (10 categories ranging from no formal schooling to doctoral degree), father's highest educational attainment at age 13 (10 categories), childhood household income at age 13 (well off, middle income, low income, poor), childhood food deprivation—assessed using the question, "When you were growing up were there times your family didn't have enough to eat?" (yes, no), household composition at age 13—based on the adults reported residing in the household and their relationship to the participant (two parent, single parent, other), immigrant status of the participant (yes, no), and mother's age at participant's birth (continuous). Adult SEP was assessed using participant's educational attainment (10 categories), participant's partner's educational attainment (when applicable; 10 categories), marital status (never married; married or living as married; widowed, divorced, or separated) and annual adult household income per person (continuous). While not always considered traditional indicators of SEP, immigrant status and maternal age at participant's birth, and participant's marital status at baseline were included as indicators of their respective SEP constructs as they are strong correlates of other traditional measures of SEP. For example, immigration status is associated with lower income and low status job sectors (Williams et al., 2010), maternal age at birth is associated with maternal educational attainment (Moore & Waite, 1977; Ou & Reynolds, 2013), and marital status is associated with accumulated wealth (Schneider, 2011).

2.4. Covariates

Covariates were selected *a priori* based on review of the literature. Baseline covariate data included self-reported race and ethnicity (non-Hispanic white, Black, Non-Black Hispanic/Latina, Other)—represented here as a social construct and used as a proxy for exposure to practices of systemic racism (Williams et al., 2016), age (continuous), and birth cohort (born pre- or post-1950). We did not adjust for any non-SEP related factors that may represent potential mediators of the childhood SEP and adult obesity pathway (i.e., smoking history, reproductive factors, etc.) to avoid overadjustment of models, acknowledging that these mediators are likely on the causal pathway and would therefore be captured in the measured association between childhood SEP and adult obesity.

3. Statistical analyses

3.1. Measurement models of childhood and adulthood SEP

We estimated measurement models for two continuous latent factors, representing childhood SEP and adult SEP, using diagonally weighted least squares confirmatory factor analysis (CFA; estimator: WLSMV; Fig. 1) (C.-H. Li, 2015). Confirmatory factor analysis is a data reduction method used to optimize the measurement of a latent construct that is predicted to influence a set of observed variables based on hypothesized relationships (Brown, 2015). Other data reduction methods, such as principal components analysis and exploratory factor analysis, tend to be more descriptive and are used to help explain the relationship between variables that might represent an underlying latent construct rather than testing a structural model of that construct (Bryant & Yarnold, 1995). We use CFA to assess how well our set of SEP variables measure SEP as an upstream construct. The use of weighted least squares estimation with robust standard errors in CFA maximizes the number of participants included in the models by using data integration methods to utilize all available data despite the presence of missing values (Asparouhov & Muthén, 2010). Mother's level of educational attainment (childhood SEP) and participant educational attainment (adult SEP) were used as referent indicators for their respective latent variables and were reverse coded (as well as other categorical variables) such that greater factor scores reflected increasing socioeconomic disadvantage. Conversely, for ease of interpretation, continuous variables were kept on their original scales (e.g., mother's age at birth and annual adult household income per person). Overall model fit was assessed using root mean square error of approximation (RMSEA, target: <0.06), comparative fit index (CFI, target: >0.95), and Tucker-Lewis Index (TLI, target: >0.95) (Hu & Bentler, 2009). We evaluated Lagrange multiplier tests (i.e., modification indices) to improve model fit by adding correlated residuals to the model. Latent variables were estimated in Mplus (version 8.6, Muthén & Muthén, Los Angeles, CA) and exported for analyses in SAS (version 9.4, SAS Institute, Cary, North Carolina, USA).

3.2. The association between childhood SEP and adult obesity: a mediation analysis

We estimated relative risk (RR) and 95% confidence intervals (CI) using log-binomial regression models for the association between childhood SEP (reported as one standard deviation change in the SEP

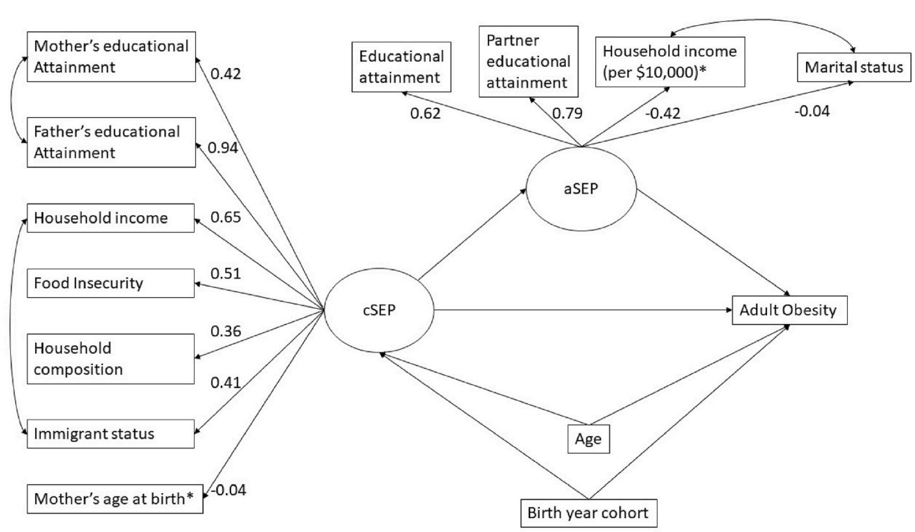

Fig. 1. Structural equation model depicting the association between childhood socioeconomic position (cSEP) and adult obesity mediated by adult socioeconomic position (aSEP). All variables except those indicated with * were inversely coded to represent socioeconomic deprivation, such that increasing overall latent variable scores represent greater deprivation. Values represent factor scores estimated using confirmatory factor analysis.

latent variable) and overweight or obese status at baseline relative to healthy weight. When models failed to converge, we used modified-Poisson regression, which provides unbiased estimates of relative risk and confidence intervals for binary outcomes (Zou, 2004). We conducted mediation analyses using a SAS macro developed by Valeri and VanderWeele (Valeri & Vanderweele, 2013) to assess path estimates and 95% bootstrap CIs for the natural direct effect (i.e., the estimated effect attributed to childhood SEP excluding all mediated pathways) of childhood SEP on adult obesity status and the natural indirect effect via adult SEP (i.e., the estimated effect of childhood SEP on adult obesity mediated by adult SEP) (See Fig. 1). Models that assessed the association between overweight or obesity compared to healthy weight were limited to participants whose measured BMI fell within the respective categories.

3.3. The association between life course SEP trajectory and adult obesity

To assess SEP over the life course, we conducted latent class analysis (LCA) to group Sister Study participants into distinct life course SEP trajectory profiles with the childhood and adult SEP variables described. We estimated five LCA models with 2–6 latent profiles with no *a priori* assumptions regarding the number of latent classes needed to optimally describe the variation in SEP profiles (Appendix A, Supplemental Table 1). Latent class models were assessed using model fit (i.e., Bayesian Information Criterion and Lo-Mendell-Rubin adjusted likelihood ratio test ($p \leq 0.05$)), class estimation criteria (i.e., entropy, ideally $\geq$0.8), and substantive groupings (Nylund-Gibson & Choi, 2018; Nylund et al., 2007; Tein et al., 2013). Using latent classes exported from Mplus, we used SAS to estimate relative risk (RR) and 95% confidence intervals (CI) using log-binomial regression models for the association between latent life course SEP profiles and overweight or obese status at baseline relative to healthy weight.

3.4. Secondary analyses

We assessed potential cohort effects using models stratified by year of birth before or after 1950, as well as estimated the association between individual measures of childhood SEP and risk of adult obesity.

4. Results

4.1. Descriptive analyses

Baseline characteristics of study participants (N = 50,864) overall and by BMI category are presented in Table 1. The study cohort was predominantly non-Hispanic White (84%), with approximately two thirds of participants classified as overweight (32%) or obese at baseline (30%). Compared to participants classified as underweight or healthy weight, participants classified as obese at baseline were more likely to identify as Black race and report indicators of low childhood SEP (e.g., parental educational attainment less than high school, low income or poor household income, and periods of food insecurity) and adult SEP (e.g., household annual income less than $20,000 per person, have less than a college degree, and be single, widowed, divorced, or separated).

4.2. The association between childhood SEP and adult obesity and mediation by adult SEP

We estimated a continuous latent variable for childhood SEP such that greater scores indicated greater social disadvantage (RMSEA: 0.04; CFI: 0.97; TLI: 0.95). Factor scores and correlated residuals are reported in Fig. 1. Relative risks for adult overweight and obesity associated with a one standard deviation change in childhood social disadvantage are presented in Table 2. Greater childhood social disadvantage, or lower childhood SEP, was associated with a 10% greater risk of overweight in adulthood (RR = 1.10, 95% CI: 1.08, 1.11) and a 16% greater risk of adult obesity (RR = 1.16, 95% CI: 1.15, 1.17), compared with healthy weight status, after adjusting for race and ethnicity, age, and birth cohort. In race and ethnicity stratified models, these associations were most apparent among non-Hispanic white participants (overweight: RR = 1.12, 95% CI: 1.10, 1.13; obese: RR = 1.19, 95% CI: 1.17, 1.20). Although elevated among both Black and non-Black Hispanic/Latina participants, the association between childhood disadvantage and adult overweight or obese were largely attenuated with 2 and 5% increased risk for overweight and 3 and 8% increased risk for obesity in models adjusted for age and birth cohort among Black and non-Black Hispanic/Latina participants, respectively (Table 2).

In mediation analyses, the adjusted relative risk for the direct effect between low childhood SEP and adult obesity was 1.10 (95% CI: 1.08, 1.12). Adult SEP mediated approximately 40% of the total effect of the measured association between low childhood SEP and adult obesity (RR = 1.06, 95% CI: 1.05, 1.06). Therefore, 60% of the observed total effect could be attributed to the direct association between low childhood SEP and adult obesity or other mediating pathways. We also observed a positive direct effect of childhood disadvantage on adult obesity in models stratified by race and ethnicity with the indirect effect via adult SEP accounting for 40% of the total effect among non-Hispanic white, 41% among Black, and 43% among non-Black Hispanic/Latina participants (Table 2).

4.3. The association between life course SEP trajectory profiles and adult obesity

To further assess the role of childhood SEP and measured adult obesity, we also evaluated the impact of SEP trajectory over the life course. The LCA model with the best combination of model fit, class estimation criteria, and interpretable substantive classes (entropy = 0.96; Lo-Mendell-Rubin adjusted likelihood ratio test <0.001; Appendix A, Supplemental Table 1) identified five distinct SEP trajectory profiles among Sister Study participants as described in Table 3. Although the six-latent class model presented better fit statistics than the five-class model, entropy was equivalent between models, and the sixth identified latent class did not substantively differ from those identified in the five-class model. Therefore, the SEP profiles were classified as (childhood SEP–adult SEP): 1) Persistent disadvantage (low–low); 2) Childhood disadvantage with greater adult advantage (low–medium); 3) Sufficient advantage (medium–medium); 4) Sufficient childhood advantage with greater adult advantage (medium–high); 5) Persistent high advantage (high–high) (See Appendix A, Supplemental Fig. 1). There was no latent class identified in which participants experienced greater disadvantage in adulthood.

Compared to the SEP profile representing persistent high advantage, adult obesity risk was higher for all other life course SEP profiles (Fig. 2). In adjusted models, the greatest risk of adult obesity was observed among those with sufficient childhood advantage with greater adult advantage (medium-high RR = 1.58, 95% CI: 1.52, 1.64) when compared to persistent high advantage. Although greater adult advantage compared to childhood did not appear to affect risk of adult obesity among participants who reported low childhood SEP (low-medium RR = 1.01, 95% CI: 0.98, 1.05) compared to those with persistent disadvantage (low-low), greater adult advantage was associated with increased adult obesity risk among participants with sufficient advantage during childhood (medium-high RR = 1.19, 95% CI: 1.15, 1.23) compared to participants with sufficient advantage over the life course (medium-medium). Similar trends were observed for non-Hispanic white participants but were less pronounced among Black and non-Black Hispanic/Latina participants (Fig. 2).

4.4. Secondary analyses

In secondary analyses, we stratified participants by birth cohort (pre and post 1950) to determine whether changes in social and economic

Table 1
Characteristics of Sister Study participants by category of body mass index at baseline (N = 50,864).

	BMI at Baseline				
	Total (%)	Underweight (%) n = 563 (1)	Healthy Weight (%) n = 18,875 (37)	Overweight (%) n = 16,149 (32)	Obese (%) n = 15,277 (30)
Personal Characteristics					
Age at Enrollment (mean, SD)	55.6 (9.0)	54.8 (9.7)	54.9 (9.2)	56.4 (8.9)	55.8 (8.6)
Birth Year Cohort					
1928–1949	22,686 (45)	240 (41)	7903 (41)	7767 (47)	6776 (44)
1950–1974	28,178 (55)	323 (59)	10,972 (59)	8382 (53)	8501 (56)
Race					
Black	4597 (8.6)	17 (2.9)	740 (3.7)	1458 (8.6)	2382 (15)
Non-Black Hispanic/Latina	2377 (4.5)	18 (2.5)	721 (3.7)	883 (5.2)	755 (4.7)
Non-Hispanic white	42,541 (84)	512 (92)	16,914 (90)	13,392 (84)	11,723 (78)
Other	1334 (2.6)	16 (2.5)	495 (2.6)	410 (2.5)	413 (2.7)
Missing	15	0	5	6	4
Height Quartiles (in inches)					
$x \leq 63$	14,255 (28)	123 (22)	4750 (25)	4651 (29)	4731 (31)
$63 < x \leq 64.58$	11,205 (22)	124 (21)	4094 (22)	3541 (22)	3446 (23)
$64.58 < x \leq 66.25$	12,903 (25)	154 (28)	4893 (26)	4106 (26)	3750 (24)
$x > 66.25$	12,501 (25)	162 (29)	5138 (28)	3851 (24)	3350 (22)
Age at Menarche					
11 years or younger	10,400 (21)	73 (13)	2872 (15)	3223 (20)	4232 (28)
12–13 years	28,513 (56)	291 (52)	10,623 (57)	9250 (57)	8349 (55)
14 years or older	11,905 (23)	199 (36)	5365 (28)	3663 (23)	2678 (17)
Missing	46	0	15	13	18
Menopause Status					
Premenopausal	17,020 (34)	199 (36)	7131 (38)	4915 (31)	4775 (32)
Postmenopausal	33,825 (67)	364 (64)	11,741 (62)	11,230 (69)	10,490 (68)
Missing	19	0	3	4	12
Annual Adult Household Income per Person					
$, Mean (SD)	42,258 (27,086)	45,557 (30,673)	44,982 (27,619)	42,601 (27,332)	38,394 (25,516)
< $20,000	12,652 (26)	130 (24)	3899 (21)	3968 (25)	4655 (31)
$20,000–39,999	20,917 (43)	208 (38)	7592 (42)	6624 (43)	6493 (44)
$40,000–50,000	343 (0.7)	6 (1.2)	212 (1.2)	87 (0.6)	38 (0.3)
> $50,000	14,942 (31)	192 (36)	6355 (35)	4785 (31)	3610 (25)
Missing	2010	27	817	685	481
Highest level of Educational Attainment					
Less than high school	627 (1.1)	9 (1.3)	148 (0.7)	202 (1.1)	268 (1.5)
Completed high school/GED	7174 (14)	56 (10)	2100 (11)	2471 (15)	2547 (16)
Some college/Associate degree	17,177 (34)	174 (31)	5368 (28)	5605 (35)	6030 (39)
College degree or above	25,874 (51)	324 (57)	11,254 (60)	7868 (49)	6428 (43)
Missing	12	0	5	3	4
Marital status					
Single, never married	2758 (5.4)	40 (6.7)	798 (4.2)	743 (4.6)	1177 (7.6)
Married, living as married	37,980 (75)	422 (76)	14,892 (79)	12,166 (75)	10,500 (69)
Widowed, divorced, separated	10,112 (20)	101 (17)	3180 (17)	3236 (20)	3595 (23)
Missing	14	0	5	4	5
Childhood Socioeconomic Factors					
Highest Level of Household Educational Attainment					
Less than high school	9310 (19)	70 (12)	2607 (14)	3214 (20)	3419 (22)
Completed high school/GED	17,988 (36)	169 (30)	6220 (33)	5785 (36)	5814 (39)
Some college/Associate degree	9496 (19)	114 (20)	3523 (19)	3051 (19)	2808 (19)
College degree or above	13,473 (27)	207 (37)	6366 (34)	3903 (24)	2997 (20)
Missing	597	3	159	196	239
Relative Childhood Household Income					
Well-off	3237 (6)	62 (11)	1534 (8.1)	922 (5.8)	719 (4.8)
Middle income	30,289 (60)	371 (67)	11,995 (64)	9372 (58)	8551 (56)
Low income	13,155 (26)	104 (19)	4275 (22)	4414 (27)	4362 (29)
Poor	4060 (7.8)	23 (4.0)	1030 (5.3)	1402 (8.4)	1605 (10)
Missing	123	3	41	39	40
Periods of Food Insecurity					
No	46,019 (91)	529 (94)	17,599 (93)	14,507 (90)	13,384 (88)
Yes	4811 (9.3)	34 (5.8)	1263 (6.6)	1634 (10)	1880 (12)
Missing	34	0	13	8	13
Childhood Household Composition					
Two parents	45,342 (89)	520 (93)	17,161 (91)	14,384 (89)	13,277 (87)
Single parent	4954 (10)	40 (7.1)	1578 (8.2)	1575 (10)	1761 (11)
Other	524 (0.9)	3 (0.4)	121 (0.6)	182 (0.9)	218 (1.3)
Missing	44	0	15	8	21
Immigrant status					

(*continued on next page*)

Table 1 (*continued*)

	BMI at Baseline				
	Total (%)	Underweight (%) n = 563 (1)	Healthy Weight (%) n = 18,875 (37)	Overweight (%) n = 16,149 (32)	Obese (%) n = 15,277 (30)
No	48,237 (95)	523 (94)	17,918 (95)	15,200 (94)	14,596 (96)
Yes	2619 (4.9)	40 (6.1)	954 (4.9)	947 (5.6)	678 (4.1)
Missing	8	0	3	2	3
Mother's age at birth					
20 or younger	2437 (4.9)	15 (2.5)	624 (3.4)	806 (5.1)	992 (6.7)
20-34	38,442 (77)	439 (80)	14,642 (79)	12,132 (77)	11,229 (76)
35+	8971 (18)	100 (18)	3342 (18)	2889 (18)	2640 (18)
Missing	1014	9	267	322	416

BMI: Body mass index; GED: General education diploma; SD: Standard deviation.

Table 2
Association between childhood SEP and adult overweight and obesity compared to healthy weight among Sister Study participants, overall and by race/ethnicity.

	Overall	Black	Non-Black Hispanic/Latina	Non-Hispanic white
	RR (95% CI)[a]	RR (95% CI)[a]	RR (95% CI)[a]	RR (95% CI)[a]
Overweight				
n	35,013	2198	1604	30,306
Crude	1.14 (1.13, 1.15)	1.04 (1.00, 1.07)	1.06 (1.02, 1.10)	1.14 (1.12, 1.15)
Adjusted[b]	1.10 (1.08, 1.11) [c]	1.02 (0.99, 1.06)	1.05 (1.01, 1.09)	1.12 (1.10, 1.13)
Obese				
n	34,143	3122	1476	28,637
Crude	1.21 (1.20, 1.22)	1.04 (1.02, 1.06)	1.09 (1.04, 1.14)	1.20 (1.18, 1.22)
Adjusted[b]	1.16 (1.15, 1.17)[c,d]	1.03 (1.01, 1.05)	1.08 (1.03, 1.13)	1.19 (1.17, 1.20)
Obese - Mediation Model[b,e]				
Direct effect	1.10 (1.08, 1.12)	1.02 (1.00, 1.04)	1.05 (1.00, 1.10)	1.12 (1.10, 1.13)
Indirect effect via adult SEP	1.06 (1.05, 1.06)	1.01 (1.01, 1.02)	1.03 (1.02, 1.05)	1.07 (1.06, 1.07)
Total effect	1.16 (1.15, 1.18)	1.03 (1.01, 1.06)	1.08 (1.03, 1.14)	1.19 (1.18, 1.21)
Proportion mediated by adult SEP	40%	41%	43%	40%

[a] Estimates are reported as relative risk associated with 1 standard deviation change in childhood social disadvantage.
[b] Models adjusted for age and birth cohort.
[c] Additionally adjusted for race and ethnicity.
[d] Modified-Poisson regression model.
[e] Bootstrap = 1000.

Table 3
Description of life course socioeconomic position (SEP) profiles identified using latent class analysis in the Sister Study cohort (N = 50,864).

Life course SEP profile (Childhood - Adult)	n (%)	Description
Persistent disadvantage (Low - Low) Mean (SD) Age, years: 57.2 (8.6)	9977 (20)	Childhood SEP • Low educational attainment, Low income or poor, Two parents • High food insecurity Adult SEP •Low educational attainment, Low income, Married
Childhood disadvantage with greater adult advantage (Low - Medium) Mean (SD) Age, years: 54.4 (9.4)	5522 (11)	Childhood SEP •High school graduate, Poor to middle income, Single parent •High food insecurity Adult SEP •At least some college, Low income, Married or previously married
Sufficient advantage (Medium - Medium) Mean (SD) Age, years: 55.2 (8.6)	14,096 (28)	Childhood SEP •High school graduate, Middle income, Two parents •Low food insecurity Adult SEP •At least some college, Middle income, Married
Sufficient childhood advantage with greater adult advantage (Medium - High) Mean (SD) Age, years: 58.2 (8.9)	8002 (16)	Childhood SEP •Low educational attainment, Middle or low income, Two parents •Moderate food insecurity Adult SEP •At least some college, Middle/High income, Single or previously married
Persistent high advantage (High - High) Mean (SD) Age, years: 53.9 (8.9)	13,267 (26)	Childhood SEP •At least some college, Well off or middle income, Two parents •Low food insecurity Adult SEP •High educational attainment, High income, Married or previously married

implications of SEP over time influenced the association between childhood SEP and overweight or obesity. Estimates were similar for participants born before and after 1950 when assessing the association between childhood SEP and adult overweight or obesity (Appendix A, Supplemental Table 2). We also evaluated the associations between individual measures of childhood SEP and adult obesity (See Appendix A, Supplemental Table 3). Increasing adult obesity risk was associated with decreasing childhood household income relative to being well-off while growing up after adjusting for age and birth cohort. These patterns were observed among non-Hispanic white and non-Black Hispanic/Latina participants in race and ethnicity-stratified models. Increased obesity risk was also associated with lower parental educational attainment (of either parent), immigrant status, and younger mothers at time of birth. In addition, the risk for adult obesity was 18% higher with report of periods of food insecurity during childhood (RR = 1.18, 95% CI: 1.13, 1.23), which was attenuated among Black participants (RR = 1.05, 95% CI: 1.00, 1.10; Appendix A, Supplemental Table 3).

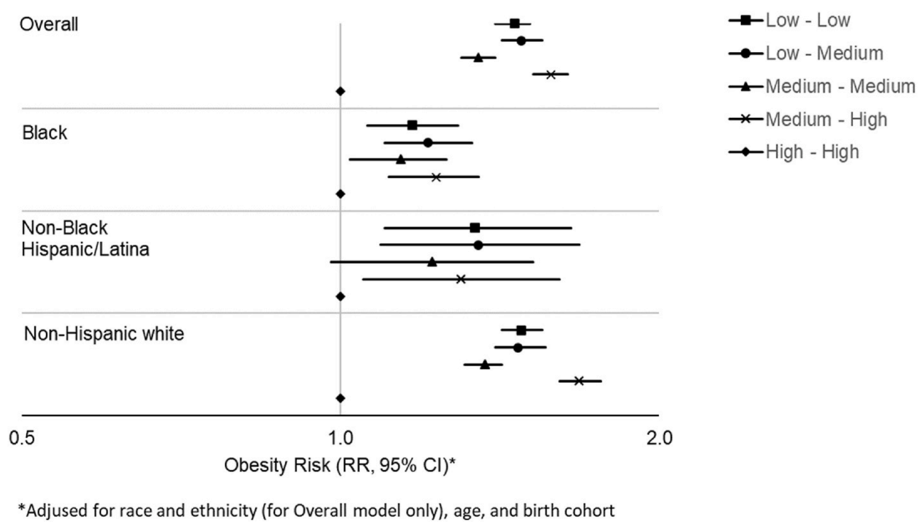

Fig. 2. Association between life course socioeconomic position (SEP) profiles and risk of obesity in adulthood (compared with healthy weight), overall and by race and ethnicity.

5. Discussion

We investigated the association between childhood SEP and adult obesity using comprehensive continuous latent variables as measures of childhood and adult SEP in a large cohort of U.S. women. Childhood SEP was associated with adult overweight and obesity in overall and race and ethnicity-stratified models. These associations were strongest among non-Hispanic white participants and were attenuated among Black or non-Black Hispanic/Latina participants, despite Black participants having the highest proportion classified as obese. Approximately 40% of the estimated effect was mediated by adult SEP overall; the proportion mediated by adult SEP was only slightly higher among Black and non-Black Hispanic/Latina participants compared to non-Hispanic white counterparts. Finally, we observed increased risk of adult obesity in relation to all life course SEP profiles compared to persistent high advantage. Together, these results support the presence of a persistent association between childhood SEP and risk of adult obesity independent of adult SEP that may act directly or via other potential mediating pathways (e.g., dietary habits, co-morbid behaviors, neighborhood effects, etc.).

Comparable to previous research using single measures of childhood SEP (Senese et al., 2009), we observed an inverse association between our latent measure of childhood SEP and adult obesity. Building on prior literature through use of mediation analysis, our results suggest that obesity risk is only partially mediated by adult SEP with much of the total effect attributable to the direct effect of childhood SEP or other potential mediating pathways, which may include associated psychosocial stress and secondary coping mechanisms. Using a life course framework, these mediating pathways may represent a chain of risk models (Kuh et al., 2003) in which childhood SEP may facilitate linked obesogenic pathways through early adulthood and middle age (e.g., low childhood SEP contributing to poor childhood diet contributing to risk of childhood obesity that discourages physical activity in early adulthood and ultimately contributing to adult obesity risk) or a model of uncorrelated events, each of which might contribute independently to adult obesity risk (e.g., changes in dietary habits due to food availability, biological priming of stress pathways that might promote fat storage, and structural barriers at the neighborhood level that inhibit physical activity). The proportion of mediated effects via adult SEP was only slightly higher for Black and non-Black Hispanic participants. This suggests that although childhood SEP results in differential risk of adult obesity by race and ethnicity, mechanisms related to adult SEP may be acting similarly to mediate the association between childhood SEP and adult obesity. Although this research focuses primarily on mediating pathways related to SEP over the life course, additional mechanisms likely exist through which childhood SEP may contribute to adult obesity risk. For example, Gavin et al. (2018) reported that the association between childhood SEP and adult obesity was primarily mediated by childhood overweight status and educational attainment among white individuals, but not African American or Asian American participants, for whom no substantial mediating effects due to adolescent risk factors (e.g., substance abuse, depression, and educational attainment) were observed.

The evidence of the role of early life SEP in adult obesity risk in studies utilizing SEP trajectory models has been mixed. Similar to our findings, a study of 2500 participants in the U.S. Panel Survey of Income Dynamics reported that less than high childhood social advantage was associated with greater risk of adult obesity despite upward mobility (M. Li et al., 2018). Conversely, findings from Australian and Brazilian cohorts reported reduced or attenuated adult obesity risk with upward social mobility (Aitsi-Selmi et al., 2013; Ball & Mishra, 2006). These might represent global differences in the relationship between social mobility and exposure to obesogenic environments and obesity prevention resources. In the US, the prevalence of obesity among adults has increased across all SEP levels (Zhang & Wang, 2004). Although upward mobility may be associated with increased access to healthy food options and built environments that promote physical activity, in general, upward social mobility is also associated with more sedentary lifestyles, which can contribute to potential weight gain. Furthermore, childhood and adolescence, and even earlier, may serve as sensitive periods when food behaviors may be solidified and metabolic adaptations have been primed to predispose individuals towards greater weight gain despite future changes in health food availability (Newnham et al., 2009). While our findings indicate that improved adult SEP was not protective of adult obesity risk when comparing those with similar substantive levels of childhood SEP, it is unclear whether these differences are due to changes in SEP between childhood and adulthood or fundamental differences in SEP profile characteristics (i.e., variability in childhood SEP variables across profiles with similar substantive classifications, such as low childhood SEP).

Previous studies have reported on the association between childhood SEP and adult obesity, however, they have relied primarily on single measures (e.g., parental education, childhood household income, etc.) as proxies for early life SEP, likely contributing to the heterogeneity in reported magnitude of the measured associations (Newton et al., 2017; Power et al., 2005; Senese et al., 2009; Trotter et al., 2010). In a previous review on the association between childhood SEP and adult obesity, 44 of the 48 studies used parental occupation as a measure of childhood SEP and only 8 considered more than one measure of childhood SEP in their analysis (Senese et al., 2009). Although the use of additional measures of SEP is more prevalent in recent literature, these measures were still primarily assessed as individual exposures (Chaffee et al., 2015; Pavela, 2017). Using individual measures of SEP can capture unique influences of those exposures on adult obesity risk, however, they do not account for how those factors may interact to reflect experienced SEP, which is a multi-dimensional construct.

5.1. Limitations and strengths

A primary limitation of this study is the lack of quantitative early life BMI data and age of obesity onset. Childhood overweight and obesity has been consistently associated with adult overweight and obesity (Singh et al., 2008), and as such, we are unable to assess how changes in SEP over the life course correspond to changes in BMI. However, although we are not able to distinguish these effects in this analysis, the mediating role of life course BMI is theoretically captured in the observed direct effect of childhood SEP on adult obesity and contributes to the potential mechanisms through which childhood SEP influences adult obesity. Second, although there is a long latency period between childhood and recalled childhood SEP measures, a study by Krieger et al. (1998) demonstrated high validity of recalled social class variables when studying adult health. Third, we did not assess neighborhood characteristics that may contribute to an obesogenic environment (Dixon et al., 2021; Hales et al., 2020), including food availability (Cooksey-Stowers et al., 2017), residential segregation, and structural racism (Bell et al., 2019; Cozier et al., 2014). An analysis of the Health and Retirement Study reported an inverse association between father's education and adult obesity risk, as we observed in our analyses, however, the effect of childhood financial hardship on adult BMI was fully attenuated after adjusting for adult SEP and neighborhood characteristics (Pavela, 2017). Additional research is needed to assess mediated effects due to modifiable environmental factors as potential intervention points in obesity prevention. Fourth, latent variables and latent classes were estimated in Mplus and exported for analyses in SAS, which can increase potential error since we do not account for error related to probability-based class assignment (Berlin et al., 2013; Nagin, 2005). Additional studies should further assess the use of latent measures of life course SEP when estimating health outcomes in adulthood.

Finally, the Sister Study population consists of women with a sister previously diagnosed with breast cancer and is generally older, more likely to report higher educational attainment, and have greater economic stability than the general US population of women. The prevalence of obesity among Sister Study participants is slightly lower than that of US women between 2003 and 2009 as estimated in the National Health and Nutrition Examination Survey (30% vs. 31–35%) (Flegal et al., 2012). Previous studies have reported lower risk of childhood obesity, a risk factor for adult obesity, among children with siblings compared to those without siblings (Bohn et al., 2022; Mosli et al., 2016). Furthermore, while overweight tends to run in families, the relationship between obesity and breast cancer is complex. Obesity in early adulthood has been associated with reduced breast cancer risk whereas postmenopausal obesity is associated with increased risk (Park et al., 2017). Due to the complex nature sibling-related obesity risk and the relationship between obesity and breast cancer risk, it is difficult to predict the impact of selecting women with a family history of breast cancer on the generalizability of our findings. However, although the characteristics of the Sister Study population may limit generalizability of the findings to the general population of US women, our findings remain internally valid (Sandler et al., 2017; Weinberg et al., 2007).

Despite these limitations, a primary strength of this study is the use of measured—not self-reported—height and weight to assess adult BMI. In addition, we also used comprehensive measures to develop latent measures of childhood and life course SEP in order to model SEP as a complex and multidimensional construct. Although single variables, such as parental education or occupation, can serve as proxies of childhood SEP, they only capture specific parts of the socioeconomic environment.

6. Conclusion

In a large cohort of US self-identified women, childhood SEP was associated with obesity in adulthood overall and in race and ethnicity stratified models. Although part of this association was mediated by adult SEP, a large proportion of the estimated effect can be attributed to the direct effect of childhood SEP or other mediating pathways. Furthermore, higher SEP in adulthood did not reduce the adult obesity risk. The results of this study suggest that socioeconomic factors, especially during childhood, may have an important role in obesity risk in adulthood.

Financial disclosures

None.

Sources of financial support

This work was supported by the Intramural Program of the National Institutes of Health, National Institute of Environmental Health Sciences, United States [grant number Z01 ES044005 [DPS]].

Declaration of competing interest

None.

Data availability

Data and code are available for replication upon request (www.sisterstudy.niehs.nih.gov)

Acknowledgements:

The authors would like to thank Drs. Kaitlyn Lawrence and Dana M. Alhasan for their review of the manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2023.101556.

References

Aitsi-Selmi, A., Batty, G. D., Barbieri, M. A., Silva, A. A., Cardoso, V. C., Goldani, M. Z., et al. (2013). Childhood socioeconomic position, adult socioeconomic position and social mobility in relation to markers of adiposity in early adulthood: Evidence of differential effects by gender in the 1978/79 ribeirao preto cohort study. *International Journal of Obesity, 37*, 439–447.

Antonoplis, S. (2023). Studying socioeconomic status: Conceptual problems and an alternative path forward. *Perspectives on Psychological Science, 18*, 275–292.

Asparouhov, T., & Muthén, B. (2010). Weighted least squares estimation with missing data. *Mplus technical appendix, 2010*, 1–10.

Ball, K., & Mishra, G. D. (2006). Whose socioeconomic status influences a woman's obesity risk: Her mother's, her father's, or her own? *International Journal of Epidemiology, 35*, 131–138.

Baltrus, P. T., Lynch, J. W., Everson-Rose, S., Raghunathan, T. E., & Kaplan, G. A. (2005). Race/ethnicity, life-course socioeconomic position, and body weight trajectories over 34 years: The alameda county study. *American Journal of Public Health, 95*, 1595–1601.

Bell, C. N., Kerr, J., & Young, J. L. (2019). Associations between obesity, obesogenic environments, and structural racism vary by county-level racial composition. *International Journal of Environmental Research and Public Health, 16*.

Ben-Shlomo, Y., & Kuh, D. (2002). A life course approach to chronic disease epidemiology: Conceptual models, empirical challenges and interdisciplinary perspectives. *International Journal of Epidemiology, 31*.

Berlin, K. S., Williams, N. A., & Parra, G. R. (2013). An introduction to latent variable mixture modeling (Part 1): Overview and cross-sectional latent class and latent profile analyses. *Journal of Pediatric Psychology, 39*, 174–187.

Bohn, C., Vogel, M., Poulain, T., Hiemisch, A., Kiess, W., & Korner, A. (2022). Having siblings promotes a more healthy weight status-Whereas only children are at greater risk for higher BMI in later childhood. *PLoS One, 17*, Article e0271676.

Brown, T. A. (2015). *Confirmatory factor analysis for applied research*. Guilford publications.

Bryant, F. B., & Yarnold, P. R. (1995). Principal-components analysis and exploratory and confirmatory factor analysis. In *Reading and understanding multivariate statistics* (pp. 99–136). Washington, DC, US: American Psychological Association.

Chaffee, B. W., Abrams, B., Cohen, A. K., & Rehkopf, D. H. (2015). Socioeconomic disadvantage in childhood as a predictor of excessive gestational weight gain and obesity in midlife adulthood. *Emerging Themes in Epidemiology, 12*, 4.

Cohen, S., Janicki-Deverts, D., Chen, E., & Matthews, K. A. (2010). Childhood socioeconomic status and adult health. *Annals of the New York Academy of Sciences, 1186*, 37–55.

Cooksey-Stowers, K., Schwartz, M. B., & Brownell, K. D. (2017). Food swamps predict obesity rates better than food deserts in the United States. *International Journal of Environmental Research and Public Health, 14*.

Cozier, Y. C., Yu, J., Coogan, P. F., Bethea, T. N., Rosenberg, L., & Palmer, J. R. (2014). Racism, segregation, and risk of obesity in the black women's health study. *American Journal of Epidemiology, 179*, 875–883.

D'Aloisio, A. A., Baird, D. D., DeRoo, L. A., & Sandler, D. P. (2010). Association of intrauterine and early-life exposures with diagnosis of uterine leiomyomata by 35 years of age in the Sister Study. *Environmental Health Perspectives, 118*, 375–381.

Dixon, B. N., Ugwoaba, U. A., Brockmann, A. N., & Ross, K. M. (2021). Associations between the built environment and dietary intake, physical activity, and obesity: A scoping review of reviews. *Obesity Reviews, 22*, Article e13171.

Flegal, K. M., Carroll, M. D., Kit, B. K., & Ogden, C. L. (2012). Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999-2010. *JAMA, 307*, 491–497.

Fryar, C., Carroll, M., & Afful, J. (2020). *Prevalence of overweight, obesity, and severe obesity among adults aged 20 and over: United States, 1960–1962 through 2017–2018*. NCHS Health E-Stats.

Galobardes, B., Shaw, M., Lawlor, D. A., Lynch, J. W., & Davey Smith, G. (2006). Indicators of socioeconomic position (Part 1). *Journal of Epidemiology & Community Health, 60*, 7–12.

Gavin, A. R., Jones, T. M., Kosterman, R., Lee, J. O., Cambron, C., Epstein, M., et al. (2018). Racial differences in mechanisms linking childhood socioeconomic status with growth in adult body mass index: The role of adolescent risk and educational attainment. *Journal of Adolescent Health, 63*, 474–481.

Hales, C. M., Carroll, M. D., Fryar, C. D., & Ogden, C. L. (2020). Prevalence of obesity and severe obesity among adults: United States, 2017-2018. *NCHS Data Brief*, 1–8.

Hu, L.t., & Bentler, P. M. (2009). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*, 1–55.

James, S. A., Fowler-Brown, A., Raghunathan, T. E., & Van Hoewyk, J. (2006). Life-course socioeconomic position and obesity in african American women: The pitt county study. *American Journal of Public Health, 96*, 554–560.

Kershaw, K. N., Albrecht, S. S., & Carnethon, M. R. (2013). Racial and ethnic residential segregation, the neighborhood socioeconomic environment, and obesity among Blacks and Mexican Americans. *American Journal of Epidemiology, 177*, 299–309.

Kind, A. J. H., & Buckingham, W. R. (2018). Making neighborhood-disadvantage metrics accessible — the neighborhood atlas. *New England Journal of Medicine, 378*, 2456–2458.

Krieger, N., Okamoto, A., & Selby, J. V. (1998). Adult female twins' recall of childhood social class and father's education: A validation study for public health research. *American Journal of Epidemiology, 147*, 704–708.

Kuh, D., Ben-Shlomo, Y., Lynch, J., Hallqvist, J., & Power, C. (2003). Life course epidemiology. *Journal of Epidemiology & Community Health, 57*, 778–783.

Li, C.-H. (2015). Confirmatory factor analysis with ordinal data: Comparing robust maximum likelihood and diagonally weighted least squares. *Behavior Research Methods, 48*, 936–949.

Li, M., Mustillo, S., & Anderson, J. (2018). Childhood poverty dynamics and adulthood overweight/obesity: Unpacking the black box of childhood. *Social Science Research, 76*, 92–104.

Moore, K. A., & Waite, L. J. (1977). Early childbearing and educational attainment. *Family Planning Perspectives*, 220–225.

Mosli, R. H., Miller, A. L., Peterson, K. E., Kaciroti, N., Rosenblum, K., Baylin, A., et al. (2016). Birth order and sibship composition as predictors of overweight or obesity among low-income 4- to 8-year-old children. *Pediatr Obes, 11*, 40–46.

Nagin, D. S. (2005). *Group-based modeling of development*. Harvard University Press.

National. (1998). Heart, Lung, and Blood Institute obesity education initiative Expert Panel on the identification, evaluation, and treatment of obesity in adults. In *Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults: The evidence report: National Institutes of health*. National Heart, Lung, and Blood Institute.

National Heart, Lung, and Blood Institute. (2013). *Managing overweight and obesity in adults: Systematic evidence review from the obesity Expert Panel*. U.S. Department of Health and Human Services, National Institutes of Health.

Newnham, J. P., Pennell, C. E., Lye, S. J., Rampono, J., & Challis, J. R. G. (2009). Early life origins of obesity. *Obstetrics & Gynecology Clinics of North America, 36*, 227–244.

Newton, S., Braithwaite, D., & Akinyemiju, T. F. (2017). Socio-economic status over the life course and obesity: Systematic review and meta-analysis. *PLoS One, 12*, Article e0177151.

Nylund-Gibson, K., & Choi, A. Y. (2018). Ten frequently asked questions about latent class analysis. *Translational Issues in Psychological Science, 4*, 440–461.

Nylund, K. L., Asparouhov, T., & Muthén, B. O. (2007). *Deciding on the number of classes in latent class analysis and growth mixture modeling: A Monte Carlo simulation study*. https://doi.org/10.1080/10705510701575396

Ogden, C. L., Fakhouri, T. H., Carroll, M. D., Hales, C. M., Fryar, C. D., Li, X., et al. (2017). Prevalence of obesity among adults, by household income and education—United States, 2011–2014. *Morbidity and Mortality Weekly Report, 66*, 1369.

Ou, S. R., & Reynolds, A. J. (2013). Timing of first childbirth and young women's postsecondary education in an inner-city minority cohort. *Urban Education, 48*.

Park, Y. M., White, A. J., Nichols, H. B., O'Brien, K. M., Weinberg, C. R., & Sandler, D. P. (2017). The association between metabolic health, obesity phenotype and the risk of breast cancer. *International Journal of Cancer, 140*, 2657–2666.

Pavela, G. (2017). Is childhood socioeconomic status independently associated with adult BMI after accounting for adult and neighborhood socioeconomic status? *PLoS One, 12*, Article e0168481.

Power, C., Graham, H., Due, P., Hallqvist, J., Joung, I., Kuh, D., et al. (2005). The contribution of childhood and adult socioeconomic position to adult obesity and smoking behaviour: An international comparison. *International Journal of Epidemiology, 34*, 335–344.

Power, C., & Parsons, T. (2000). Nutritional and other influences in childhood as predictors of adult obesity. *Proceedings of the Nutrition Society, 59*, 267–272.

Reither, E. N., Hauser, R. M., & Yang, Y. (2009). Do birth cohorts matter? Age-period-cohort analyses of the obesity epidemic in the United States. *Social Science & Medicine, 69*, 1439–1448.

Robinson, W. R., Utz, R. L., Keyes, K. M., Martin, C. L., & Yang, Y. (2013). Birth cohort effects on abdominal obesity in the United States: The silent generation, baby boomers and generation X. *International Journal of Obesity, 37*, 1129–1134.

Sandler, D. P., Hodgson, M. E., Deming-Halverson, S. L., Juras, P. S., D'Aloisio, A. A., Suarez, L. M., et al. (2017). The sister study cohort: Baseline methods and participant characteristics. *Environmental Health Perspectives, 125*, Article 127003.

Scharoun-Lee, M., Kaufman, J. S., Popkin, B. M., & Gordon-Larsen, P. (2009). Obesity, race/ethnicity and life course socioeconomic status across the transition from adolescence to adulthood. *Journal of Epidemiology & Community Health, 63*, 133–139.

Schneider, D. (2011). Wealth and the marital divide. *Ajs, 117*, 627–667.

Senese, L. C., Almeida, N. D., Fath, A. K., Smith, B. T., & Loucks, E. B. (2009). Associations between childhood socioeconomic position and adulthood obesity. *Epidemiologic Reviews, 31*, 21–51.

Singh, A. S., Mulder, C., Twisk, J. W., van Mechelen, W., & Chinapaw, M. J. (2008). Tracking of childhood overweight into adulthood: A systematic review of the literature. *Obesity Reviews, 9*, 474–488.

Sullivan, S. M., Brashear, M. M., Broyles, S. T., & Rung, A. L. (2014). Neighborhood environments and obesity among afro-caribbean, african American, and non-hispanic white adults in the United States: Results from the national Survey of American life. *Preventive Medicine, 61*, 1–5.

Tein, J. Y., Coxe, S., & Cham, H. (2013). Statistical power to detect the correct number of classes in latent profile analysis. *Structural Equation Modeling, 20*, 640–657.

Trotter, L. J., Bowen, D. J., & Beresford, S. A. (2010). Testing for racial/ethnic differences in the association between childhood socioeconomic position and adult adiposity. *American Journal of Public Health, 100*, 1088–1094.

Valeri, L., & Vanderweele, T. J. (2013). Mediation analysis allowing for exposure-mediator interactions and causal interpretation: Theoretical assumptions and implementation with SAS and SPSS macros. *Psychological Methods, 18*, 137–150.

Weinberg, C., Shore, D., Umbach, D., & Sandler, D. (2007). Using risk-based sampling to enrich cohorts for endpoints, genes, and exposures. *American Journal of Epidemiology, 166*.

Williams, D. R., Mohammed, S. A., Leavell, J., & Collins, C. (2010). Race, socioeconomic status, and health: Complexities, ongoing challenges, and research opportunities. *Annals of the New York Academy of Sciences, 1186*, 69–101.

Williams, D. R., Priest, N., & Anderson, N. B. (2016). Understanding associations among race, socioeconomic status, and health: Patterns and prospects. *Health Psychology, 35*, 407–411.

Zhang, Q., & Wang, Y. (2004). Trends in the association between obesity and socioeconomic status in U.S. Adults: 1971 to 2000. *Obesity Research, 12*, 1622–1632.

Zou, G. (2004). A modified Poisson regression approach to prospective studies with binary data. *American Journal of Epidemiology, 159*, 702–706.