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Cumulative Socioeconomic (Dis)Advantage and Metabolic Syndrome among Midlife Women
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Steering Committee: Susan Johnson, Current Chair; Chris Gallagher, Former Chair.

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ABSTRACT

More than 20% of U.S. adults have metabolic syndrome (MetS). Among women, a strong predictor of MetS is their socioeconomic status (SES); the role of childhood SES is unclear. Using data from the prospective Study of Women’s Health Across the Nation, we examined whether childhood and adult SES were associated with MetS among white and black women during 12 years in midlife. Childhood SES was measured by three latent classes. Adult SES was measured by education. We assessed whether the associations could be statistically accounted for by adult reproductive, economic, behavioral, and psychosocial factors. We estimated odds of MetS at pre/early-menopausal baseline in 1996-1997 with logistic regression and incidence through 2010-2011 with Cox proportional hazards models. Women raised in “adverse” SES had marginally greater odds of MetS at baseline (odds ratio = 1.46, 95% confidence interval: 0.92, 2.31) than women raised in “good” SES, and women with a high school credential or less had significantly greater odds (odds ratio = 1.76, 95% confidence interval: 1.17, 2.66) than college-educated women, in mutually adjusted models. The elevated odds partly reflected SES-related differences in exercise and alcohol consumption. Incidence was associated with education, not childhood SES, and unaccounted for by the adult factors.
INTRODUCTION

More than 1 in 5 U.S. adults have metabolic syndrome (MetS) (1), a cluster of cardiometabolic risk factors for chronic illnesses, such as diabetes and cardiovascular disease, as well as death (2, 3). The risk of having MetS increases substantially during midlife (1) and its health consequences are especially pronounced among postmenopausal women (4). Better knowledge about the predictors of MetS could help patients and providers prevent its development and improve the health of U.S. adults, especially older women, one of the largest and fastest growing segments of the population.

A well-established predictor of MetS among women is their socioeconomic status (SES), particularly their education level (5-12). Indeed, education is “among the most important preventive factors in social epidemiology” (13, p. 222). Education is thought to enhance health largely through indirect pathways such as economic well-being, health-related behaviors, and psychosocial resources (14, 15). Compared to lower-educated peers, higher-educated adults are more likely to be employed and have an adequate income for purchasing nutritious foods, gym memberships, and other salubrious resources (16). Higher-educated adults are less likely to engage in risky behaviors such as smoking and are more likely to engage in preventive behaviors (17). Higher-educated women have fewer children (18) and later age of natural menopause (19), which may protect against MetS. Schooling also enhances psychosocial resources. Higher-educated adults are more likely to have positive social ties (20) and less likely to experience depression (21). In addition to indirect pathways, schooling may have direct physiological benefits (22, 23).

Recent studies have examined whether childhood SES predicts MetS in adulthood (7, 9, 24, 25). Childhood SES predicts several health consequences of MetS in adulthood, such as diabetes (26), cardiovascular disease (27), and mortality (28); thus, it may also predict the risk of MetS. Some studies suggest that childhood SES can become biologically embedded (e.g., through inadequate nutrition, chronic stress) with enduring consequences for metabolic and cardiovascular functioning (25, 29). In addition, childhood SES may be important for adult health because individuals from high (low) childhood SES tend to achieve high (low) SES as adults. Adverse childhood SES is also associated with reproductive factors among women, such as higher fertility and an earlier age of menopause (30), which may increase the risk of MetS.
The few studies that have investigated the role of childhood SES for MetS are inconclusive, which may reflect differences in childhood SES measures and respondent ages (7, 9, 24, 25). With few exceptions (31), studies have used either parental education (25, 32, 33) or occupation (7, 9, 24, 34) as a single indicator of childhood SES, but these indicators can have different implications for a child’s physiological and social development. Parental education may reflect cognitive stimulation in the home, parenting styles, and routine meal and bed times. Parental occupation may more closely reflect economic circumstances. Moreover, prior studies have been either cross-sectional or prospective follow-up studies that assessed MetS at a single age. Any potential effect of childhood SES on the risk of MetS may change with age. The effect may strengthen with age as the prevalence of MetS among women increases after menopause (35) or decline with age as the proportion of life spent in childhood shrinks.

This longitudinal study examines whether childhood and adult SES predict MetS among women during midlife. It provides new evidence by: a) examining the associations prospectively across a 12-year period where MetS was repeatedly assessed, b) developing a meaningful measure of childhood SES that summarizes multiple dimensions of the SES environment, and c) assessing whether the associations can be statistically accounted for by four adult factors: reproductive, economic, behavioral, and psychosocial.

**METHODS**

**Data**

The Study of Women’s Health Across the Nation (SWAN) is a multi-site, community-based, prospective study of aging and the menopause transition. From a cross-sectional study of 16,065 women from seven locations (Boston, Chicago, the Detroit area, Los Angeles, New Jersey, Oakland, and Pittsburgh), 3302 women who at the 1996 baseline were aged 42-52 years, premenopausal, and self-identified with the site’s designated race-ethnic groups were recruited for the prospective study. Details on sampling and recruitment methods are published elsewhere (36). Study visits between baseline and follow-up assessment 13 included interviews, anthropometry, questionnaires, and blood draws. The analytical sample for the present study includes black and white women from 4 SWAN locations (Boston, Chicago, Detroit, Pittsburgh) that administered an ancillary 10-item questionnaire about childhood circumstances during visit 13 in 2012/13. Among these 1399 participants, 1109 (79%) returned the ancillary questionnaire.
Metabolic Syndrome

Metabolic syndrome (MetS) is defined as having at least three of the following five components: hypertension (systolic blood pressure ≥ 130 mmHg or diastolic blood pressure ≥ 85 mmHg or taking any blood pressure medication), impaired fasting glucose (glucose ≥ 100 mg/dL fasting value), obesity (waist > 88 cm), low HDL (< 50 mg/dL), and high triglycerides (≥150 mg/dL fasting value). MetS was measured at baseline and at each follow-up through visit 12. For missed visits, the score is imputed if the participant was known to have MetS in prior visits (imputed score = 1) or if the participant was known to not have MetS in both prior and subsequent visits (imputed score = 0).

Childhood Circumstances

Information on childhood circumstances was collected during visit 13 in 2012/2013 with a 10-item questionnaire, the SWAN Childhood Context Ancillary Study. To assess childhood SES, it asked participants about their mother’s and father’s education and whether, before age 19, their childhood family owned a car, owned a home, ever received public assistance, and ever had difficulty paying for food or rent. Retrospective recalls of childhood SES and specific events are considered reliable and accurate (37-40). The SWAN childhood SES questions had also been administered at visit 7 to 259 women at the Pittsburgh site. The concordance of the questions between visits 7 and 13 ranged from 86.1 to 96.9% among those participants.

We conducted a latent class analysis to identify distinct subgroups of childhood SES among SWAN participants. This approach is often preferable to alternatives such as including all SES indicators in multivariate analyses (running the risk of multicollinearity) or creating a summation index of the indicators (ignoring their natural clustering). Following recommended procedures (41) using Mplus (42), we found that three latent classes provided the best fit, had good classification quality, and are substantively meaningful. Class 1 contains 26%, class 2 contains 50%, and class 3 contains 24% of women. Characteristics of the classes are shown in Table 1. Class 1 is the most disadvantaged, consisting of women with low-educated, poor parents (“adverse SES”). Class 2 contains women with low-educated, non-poor parents (“fair SES”). Class 3 is the most advantaged, with high-educated, non-poor parents (“good SES”).
### Table 1. Distribution of Demographics and Childhood SES Indicators at Baseline (1996-1997) Among SWAN Participants in Pittsburgh, Detroit, Boston, and Chicago (n=1109)

<table>
<thead>
<tr>
<th>Childhood SES latent class</th>
<th>Full Sample</th>
<th>Parents low-educated and poor</th>
<th>Parents low-educated, not poor</th>
<th>Parents high-educated, not poor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(&quot;adverse&quot;)</td>
<td>(&quot;fair&quot;)</td>
<td>(&quot;good&quot;)</td>
<td></td>
</tr>
<tr>
<td>Father’s education (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than high school</td>
<td>28.5</td>
<td>37.9</td>
<td>37.4</td>
<td>3.2</td>
</tr>
<tr>
<td>High school credential</td>
<td>27.9</td>
<td>22.2</td>
<td>43.3</td>
<td>6.2</td>
</tr>
<tr>
<td>Technical or vocational school</td>
<td>5.1</td>
<td>1.8</td>
<td>8.3</td>
<td>3.0</td>
</tr>
<tr>
<td>Some college</td>
<td>10.3</td>
<td>6.5</td>
<td>8.0</td>
<td>18.0</td>
</tr>
<tr>
<td>Bachelor’s degree</td>
<td>10.8</td>
<td>3.8</td>
<td>0.0</td>
<td>37.0</td>
</tr>
<tr>
<td>Postgraduate degree</td>
<td>8.7</td>
<td>2.4</td>
<td>0.0</td>
<td>30.6</td>
</tr>
<tr>
<td>Don’t know</td>
<td>8.7</td>
<td>25.4</td>
<td>3.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Mother’s education (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than high school</td>
<td>26.4</td>
<td>41.2</td>
<td>31.1</td>
<td>3.3</td>
</tr>
<tr>
<td>High school credential</td>
<td>39.0</td>
<td>32.0</td>
<td>50.0</td>
<td>26.7</td>
</tr>
<tr>
<td>Technical or vocational school</td>
<td>7.2</td>
<td>4.9</td>
<td>8.3</td>
<td>7.7</td>
</tr>
<tr>
<td>Some college</td>
<td>11.0</td>
<td>5.4</td>
<td>8.3</td>
<td>21.4</td>
</tr>
<tr>
<td>Bachelor’s degree</td>
<td>7.6</td>
<td>2.7</td>
<td>1.4</td>
<td>23.4</td>
</tr>
<tr>
<td>Postgraduate degree</td>
<td>4.6</td>
<td>1.1</td>
<td>0.0</td>
<td>16.2</td>
</tr>
<tr>
<td>Don’t know</td>
<td>4.1</td>
<td>12.6</td>
<td>0.9</td>
<td>1.4</td>
</tr>
<tr>
<td>Childhood family…(%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>…did not own a car</td>
<td>13.5</td>
<td>38.6</td>
<td>5.4</td>
<td>2.7</td>
</tr>
<tr>
<td>…did not own a home</td>
<td>20.8</td>
<td>61.2</td>
<td>7.4</td>
<td>4.4</td>
</tr>
<tr>
<td>…ever received public assistance</td>
<td>19.1</td>
<td>59.2</td>
<td>6.8</td>
<td>1.0</td>
</tr>
<tr>
<td>…ever had difficulty paying for food or rent</td>
<td>35.7</td>
<td>76.1</td>
<td>23.6</td>
<td>16.9</td>
</tr>
<tr>
<td>Race (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>56.1</td>
<td>31.0</td>
<td>58.9</td>
<td>77.3</td>
</tr>
<tr>
<td>Black</td>
<td>43.9</td>
<td>69.0</td>
<td>41.1</td>
<td>22.7</td>
</tr>
<tr>
<td>SWAN location (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boston</td>
<td>27.0</td>
<td>27.0</td>
<td>21.9</td>
<td>37.5</td>
</tr>
<tr>
<td>Chicago</td>
<td>14.0</td>
<td>12.7</td>
<td>13.5</td>
<td>16.4</td>
</tr>
<tr>
<td>Detroit</td>
<td>31.1</td>
<td>39.3</td>
<td>34.0</td>
<td>16.3</td>
</tr>
<tr>
<td>Pittsburgh</td>
<td>27.9</td>
<td>21.0</td>
<td>30.6</td>
<td>29.8</td>
</tr>
<tr>
<td>Participants’ educational attainment (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school or less</td>
<td>20.9</td>
<td>31.5</td>
<td>22.7</td>
<td>5.8</td>
</tr>
<tr>
<td>Some college</td>
<td>35.1</td>
<td>41.2</td>
<td>38.0</td>
<td>22.5</td>
</tr>
<tr>
<td>Bachelor’s degree or higher</td>
<td>44.0</td>
<td>27.3</td>
<td>39.3</td>
<td>71.7</td>
</tr>
<tr>
<td>Metabolic syndrome at baseline (%)a</td>
<td>24.6</td>
<td>33.1</td>
<td>23.2</td>
<td>18.1</td>
</tr>
<tr>
<td>N</td>
<td>1109</td>
<td>294</td>
<td>552</td>
<td>263</td>
</tr>
</tbody>
</table>

Abbreviations: SES, socioeconomic status; SWAN, Study of Women’s Health Across the Nation.

a Among the 1077 participants with non-missing MetS scores.
**Adult Circumstances**

The adult factor of main interest is women’s *educational attainment*. It is categorized into high school or less; some college; a bachelor’s degree or higher. In addition, we include four factors, described below, which may statistically account for the associations between childhood SES, women’s education, and MetS. We select several measures of these factors based on prior literature and data availability within SWAN. All measures are taken from the baseline visit except hormone use and menopausal status, which are time-varying.

We include three reproductive factors. *Number of live births* is a 6-category measure, from 0 to 5 or more. We include an indicator of *hormone use* (including birth control) in the month preceding each visit. At each visit women are classified into one of four *menopausal status* categories based on bleeding patterns: pre- or early peri-menopausal, late peri-menopausal, post- or surgical menopause, and unknown due to hormone therapy.

We include two measures of economic well-being. *Employment* indicates whether the participant was employed during the two weeks prior to baseline. *Economic hardship* identifies participants who stated they experienced “major money problems” during the prior year.

We include four health-related behaviors. *Smoking* indicates the participant smoked cigarettes regularly. *Alcohol consumption* is measured with five categories: abstainer, infrequent (<2 servings / week), light to moderate (2 to 7 servings / week), heavy (>7 servings / week), and other. *Sleep quality* is a 5-level ordinal measure ranging from very sound to very restless. *Physical activity* measures how often the participant played sports or exercised during the year before baseline. The categories include: never, less than once a month, once a month, 2-3 times a month, once a week, and more than once a week.

We include three psychosocial resources. *Marital status* includes never married, currently married, previously married, and other. *Social support* is based on four questions about having someone to listen to when you need to talk; take you to the doctor; confide in; help with daily chores if you were sick. Responses to each question range from none of the time (0) to all of the time (4) and are summed to a score ranging from 0 to 16. *Depression* is measured with the 20-item Center for Epidemiologic Studies - Depression (CES-D) scale (43).
Analytic Strategy

Prevalence of MetS at Baseline. We first assess the extent to which childhood SES and women’s education predict MetS at baseline when all women were pre- or early-menopausal. Of the 1099 participants in the Childhood Context Ancillary Study, 1077 had a MetS score at baseline; 1028 of them (or 95.5%) had complete data on all covariates and are included in the prevalence analysis. We examine the odds of MetS at baseline using logistic regression. Model 1 estimates the odds of MetS from childhood SES. Model 2 adds education to model 1. Models 3-7 include adult factors. The models do not adjust for menopausal status or hormone use because at baseline participants were pre/early menopausal and not using hormones. All models adjust for age, race, and SWAN location, and were estimated with SAS 9.4.

Incidence of MetS after Baseline. We next examine the degree to which childhood SES and women’s education predict the incidence of MetS after baseline. This analysis includes participants without MetS at baseline plus participants who were missing MetS at baseline and did not have MetS in the first visit it was assessed. Among these 834 participants, 802 (96.1%) had complete data on all predictor variables and are included in the incidence analysis. At the time of this study, MetS information for visit 13 was not available. We estimate Cox proportional hazards models using elapsed age between visits as the time metric. Model 1 estimates the hazard of MetS from childhood SES. Model 2 adds education to model 1. Models 3-7 add adult factors. All models adjust for age, race, and SWAN location, and were estimated with SAS 9.4.

RESULTS

At baseline, 265 of 1077 SWAN participants (24.6%) had MetS. Table 1 shows a graded association between childhood SES and MetS at baseline. The prevalence of MetS was 33.1, 23.2, and 18.1% among women raised in adverse, fair, and good childhood SES, respectively. Among the 1028 respondents with complete data for all covariates at baseline, 24.0% had MetS. After baseline, 259 of 802 participants (32.3%) developed MetS.

Prevalence Analysis

Model 1 in Table 2 estimates the basic association between childhood SES and the odds of MetS at baseline, controlling for age, race, and location. Compared to women raised
in good childhood SES, the odds of MetS are 73% higher among women raised in adverse SES ($P \leq 0.05$) and the odds are a non-significant 14% higher among women raised in fair SES. In model 2 the elevated odds of MetS among women raised in adverse SES are attenuated when education is included. Adjusting for education attenuates the log-odds coefficient for adverse SES between models 1 and 2 by 31%. Nonetheless, adverse SES remains elevated (OR[odds ratio]=1.46, $P \leq 0.10$) and education remains significant (OR for high school or less=1.76, $P \leq 0.01$; OR for some college = 1.48, $P \leq 0.05$).

Models 3-6 assess whether the four adult factors statistically account for the associations between childhood SES, education, and MetS in model 2. Model 3 adjusts for reproductive factors (measured by number of live births) but does not attenuate the size or significance of the associations. Among the remaining three adult factors, health behaviors (Model 5) appear to be most important. Adjusting for behaviors reduces the log-odds for adverse childhood SES by 25% and to statistical non-significance. It reduces the log-odds for high school or less by 29% and to marginal significance. Controlling for all four types of adult factors (models not shown) did not attenuate the associations more than model 5.

Among the four behaviors in model 5, exercise and alcohol are significantly related to MetS but smoking (OR=1.20, $P > 0.10$) and sleep (OR=1.01, $P > 0.10$) are not (full models available on request). In general, the odds of MetS decline with exercise frequency and alcohol consumption. For instance, compared to women who exercised multiple times per week, women who exercised once per week have more than double the odds of MetS (OR=2.22, $P \leq 0.01$) and women who never exercised have more than triple the odds (OR=3.11 $P \leq 0.001$). Compared to women who consumed light-to-moderate amounts of alcohol, women who abstained have 1.80 times the odds of MetS ($P \leq 0.01$).

We conducted ancillary analyses to glean additional insights. First, although we did not hypothesize that SES differentials in access to health insurance or prescription medications for MetS components (e.g., cholesterol, diabetes, hypertension) accounted for the elevated odds of MetS among SES disadvantaged women, we tested this possibility and found little support. Second, we examined whether childhood SES and women's education had a synergistic association with MetS. Only one of the four SES-by-education interaction terms was significant ("adverse SES-by-high school or less" OR < 1.00, $P \leq 0.05$) and the interaction as a whole did not improve model fit.
### Table 2. Odds of Having Metabolic Syndrome at Baseline (1996-1997) by Childhood SES and Women’s Educational Attainment Among SWAN Participants in Pittsburgh, Detroit, Boston, and Chicago (n=1028)

<table>
<thead>
<tr>
<th>Modela</th>
<th>OR (95% CI)</th>
<th>OR (95% CI)</th>
<th>OR (95% CI)</th>
<th>OR (95% CI)</th>
<th>OR (95% CI)</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Childhood SES**&lt;br&gt;Good</td>
<td>1.00</td>
<td>Referent</td>
<td>1.00</td>
<td>Referent</td>
<td>1.00</td>
</tr>
<tr>
<td>2</td>
<td>1.14</td>
<td>0.77, 1.70</td>
<td>1.02</td>
<td>0.68, 1.54</td>
<td>0.99</td>
<td>0.66, 1.50</td>
</tr>
<tr>
<td>3</td>
<td>1.73*</td>
<td>1.11, 2.69</td>
<td>1.46†</td>
<td>0.92, 2.31</td>
<td>1.49†</td>
<td>0.94, 2.36</td>
</tr>
<tr>
<td>4</td>
<td>Educational attainment&lt;br&gt;Bachelors or more</td>
<td>1.00</td>
<td>Referent</td>
<td>1.00</td>
<td>Referent</td>
<td>1.00</td>
</tr>
<tr>
<td>5</td>
<td>1.48*</td>
<td>1.03, 2.12</td>
<td>1.53*</td>
<td>1.06, 2.20</td>
<td>1.44*</td>
<td>1.00, 2.07</td>
</tr>
<tr>
<td>6</td>
<td>1.76**</td>
<td>1.17, 2.66</td>
<td>1.85**</td>
<td>1.22, 2.81</td>
<td>1.71**</td>
<td>1.13, 2.61</td>
</tr>
<tr>
<td>7</td>
<td>AIC</td>
<td>1115</td>
<td>1111</td>
<td>1116</td>
<td>1110</td>
<td>1085</td>
</tr>
</tbody>
</table>

**Abbreviations:** AIC, Akaike Information Criterion; CI, confidence interval; OR, odds ratio; SES, socioeconomic status; SWAN, Study of Women’s Health Across the Nation.

**P** ≤ 0.001; **P** ≤ .01; *P* ≤ 0.05; †*P* ≤ 0.10

**a** Model 1 adjusts for race, SWAN location, and age at baseline.

Model 2 adds educational attainment to model 1.

Model 3 adds number of live births to model 2.

Model 4 adds economic well-being (employment, economic hardship) to model 2.

Model 5 adds health behaviors (smoking, alcohol, sleep, exercise) to model 2

Model 6 adds psychosocial resources (marital status, social support, depression) to model 2.

**b** All participants are classified into one of three latent classes of childhood SES. See Table 1 for a description of each class.
Incidence Analysis

Model 1 in Table 3 estimates the basic association between childhood SES and the risk of developing MetS after baseline, controlling for race and SWAN location. Compared to women raised in good SES, women raised in adverse SES have an elevated hazard of MetS but the difference is not significant (HR[hazard ratio]=1.22, \textit{P}\textgreater{}0.10). In contrast to childhood SES, education is a significant predictor. In model 2, net of childhood SES, women with a high school or less education have 57\% higher risk of MetS (\textit{P}\leq0.05), and women with some college have a 34\% higher risk (\textit{P}\leq0.10), compared to college-educated women.

Similar to the prevalence results, adjusting for reproductive factors (births, time-varying hormone use and menopausal status) in model 3 does not attenuate the association. Because of the theoretical importance of those measures, we retain them in all subsequent models. Unlike the prevalence analysis, the elevated risk of MetS for women without a college degree is changed little by adjusting for the four adult factors. Even when controlling for health behaviors in model 5, the elevated log-hazard is just 9\% smaller than it is in model 3. Lastly, we estimated ancillary models similar to those in the prevalence analysis. Educational differentials in health insurance and medications did not account for the elevated hazards, and we did not find strong evidence for SES-by-education interactions.

Collectively, the results illustrate a strong and persistent association between education and MetS incidence. The association is even clearer when examining survival probabilities. Table 4 shows the probability of surviving from baseline to at least age 50, 55, and 60 without developing MetS (probabilities derived from model 2 in Table 3 using the reference values for race (black) and location (Pittsburgh). The probability of surviving without MetS to age 50 ranged from 89\% among women with good childhood SES and a college degree to 82\% among women with adverse childhood SES and low education. The differences grew with age: probability of surviving to age 65 without MetS ranged from 72 to 57\%.
Table 3. Hazard of Metabolic Syndrome After Baseline (1996-1997) Through 2010-2011 by Childhood SES and Women’s Educational Attainment Among SWAN Participants in Pittsburgh, Detroit, Boston, and Chicago (n=802)

<table>
<thead>
<tr>
<th>Childhood SES</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
<th>Model 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
</tr>
<tr>
<td>Fair</td>
<td>1.03</td>
<td>0.74, 1.42</td>
<td>0.93</td>
<td>0.67, 1.30</td>
<td>0.94</td>
<td>0.67, 1.32</td>
</tr>
<tr>
<td>Adverse</td>
<td>1.22</td>
<td>0.84, 1.77</td>
<td>1.05</td>
<td>0.71, 1.56</td>
<td>1.10</td>
<td>0.74, 1.63</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Educational attainment</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
<th>Model 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bachelors or more</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
</tr>
<tr>
<td>Some college</td>
<td>1.34†</td>
<td>0.99, 1.80</td>
<td>1.43*</td>
<td>1.06, 1.94</td>
<td>1.42*</td>
<td>1.05, 1.92</td>
</tr>
<tr>
<td>High school or less</td>
<td>1.57*</td>
<td>1.11, 2.23</td>
<td>1.69**</td>
<td>1.18, 2.40</td>
<td>1.75**</td>
<td>1.22, 2.52</td>
</tr>
<tr>
<td>AIC</td>
<td>3223</td>
<td>3220</td>
<td>3201</td>
<td>3197</td>
<td>3205</td>
<td>3189</td>
</tr>
</tbody>
</table>

Abbreviations: AIC, Akaike Information Criterion; CI, confidence interval; HR, hazards ratio; SES, socioeconomic status; SWAN, Study of Women’s Health Across the Nation.

***P ≤ 0.001; **P ≤ .01; *P ≤ 0.05; †P ≤ 0.10

a Model 1 adjusts for race and SWAN location.
Model 2 adds educational attainment to model 1.
Model 3 adds reproductive function (live births, menopausal status, hormone use) to model 2.
Model 4 adds economic well-being (employment, economic hardship) to model 3.
Model 5 adds health behaviors (smoking, alcohol, sleep, exercise) to model 3.
Model 6 adds psychosocial resources (marital status, social support, depression) to model 3.

b All participants are classified into one of three latent classes of childhood SES. See Table 1 for a description of each class.
Table 4. Probability of Surviving from Baseline (1996-1997) Until at Least Age 50, 55, and 60 Without Developing Metabolic Syndrome by Childhood SES and Women’s Educational Attainment Among SWAN Participants in Pittsburgh, Detroit, Boston, and Chicago (n=802)

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Adverse childhood SES and high school or less</th>
<th>Fair childhood SES and some college</th>
<th>Good childhood SES and college or more</th>
<th>Columns (C) – (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>82.4</td>
<td>86.8</td>
<td>89.1</td>
<td>6.7</td>
</tr>
<tr>
<td>55</td>
<td>68.7</td>
<td>75.9</td>
<td>79.9</td>
<td>11.2</td>
</tr>
<tr>
<td>60</td>
<td>57.4</td>
<td>66.6</td>
<td>71.7</td>
<td>14.3</td>
</tr>
</tbody>
</table>

Abbreviations: SES, socioeconomic status; SWAN, Study of Women’s Health Across the Nation.

Survival probabilities were generated from Cox proportional hazards models in SAS PROC PHREG that included childhood SES, educational attainment, race, and SWAN location (i.e., model 2 in Table 3). The probabilities are estimated at the reference values for race (black) and location (Pittsburgh).

**DISCUSSION**

This study examined whether childhood and adult SES (measured by education level) have enduring consequences for MetS among midlife women. It provides new evidence on the life course origins of MetS by: a) using a prospective dataset containing repeated measures of MetS, b) assessing how childhood and adult SES predict the odds of MetS at study baseline when women were pre/early-menopausal, as well as the subsequent risk of developing MetS, c) creating a measure of childhood SES that is multidimensional and meaningful, and d) examining whether the associations can be statistically accounted for by adult reproductive, economic, behavioral, and psychosocial factors.

Both childhood SES and women’s education were inversely related to MetS at baseline. Compared with women who grew up in “good” circumstances (high-educated, non-poor parents), women who grew up in “fair” circumstances (low-educated, non-poor parents) had marginally higher odds of MetS, while women who grew up in “adverse” circumstances (low-educated, poor parents) had significantly greater odds. As the primary distinction between fair and adverse childhood SES was economic hardship, it appears that
economic hardship in childhood, rather than low levels of parental education alone, has
pernicious and enduring consequences for women’s metabolic health. It is important to
note that our analysis did not include women raised by high-educated, poor parents. Thus,
we cannot assess whether economic hardship in childhood would have similarly
deleterious consequences for women with high-educated parents or if high-educated
parents could buffer against such consequences. While childhood SES and education
predicted the odds of MetS at baseline, only education predicted incident MetS after
baseline. Childhood SES appears to be less relevant than education for later onset MetS and
metabolic health generally, particularly as women traverse the menopause transition.

The association between childhood SES and the odds of MetS at baseline appears to
largely reflect a pathway of low education and unhealthy behaviors. Accounting for
education and behaviors attenuated the adverse childhood SES coefficient by roughly one-
half; and while it was no longer statistically significant the odds remained elevated
(OR=1.33). Similarly, the association between women’s education and MetS at baseline was
largely accounted for by behaviors rather than other factors we examined. Frequent
exercise and light-to-heavy alcohol consumption predicted lower odds of MetS; and SES-
disadvantaged women were less likely to exercise and more likely to abstain. Our finding is
consistent with studies of health behavior clusters, which document a positive correlation
between exercise and alcohol (44-46) which is thought to reflect an active lifestyle that
often mixes team sports (e.g., running clubs, tennis) with socializing centered on alcohol
consumption (45, 46). Indeed, the correspondence between alcohol consumption and
exercise frequency among SWAN participants is significant (Spearman ρ = 0.11, P≤0.001).
These patterns may help explain the association between education and MetS because
higher-educated women were more likely to exercise and less likely to abstain than their
lower-educated peers.

Although health behaviors partly accounted for the inverse relationship between
participants’ education and incident MetS, other adult factors did not. Prior research has
similarly found that even when controlling for health behaviors and number of live births,
education remains a significant predictor of women’s MetS (6). Education may have other
indirect, and possibly direct, benefits for metabolic health that are difficult to account for
empirically. Nonetheless, the findings underscore the importance of education for
metabolic health and as a straightforward diagnostic for clinicians in assessing MetS risk.
Also noteworthy is that SES disparities in MetS widen with age. The difference in surviving without MetS between the most and least advantaged women nearly doubled between ages 50 and 60. The divergence illustrates the enduring, cumulative effects of socioeconomic conditions on women’s metabolic health. It also underscores the need to consider the age of respondents in studies examining the life course socioeconomic origins of metabolic health.

**Limitations**

One potential limitation of our study is that childhood indicators were retrospectively reported. However, prior studies find that retrospective measures of childhood SES are reliable (39) and accurate (37). Other indicators, such as childhood obesity, were not measured but could be potentially important. The survey contains limited information on adult SES other than education; however, studies comparing education, income, and occupation find education is the strongest (24) or only (7) predictor of MetS. Moreover, education data are available for all women regardless of age or employment, education is temporally prior to income and occupation, and is least affected by declining health (16). As our study is based on four U.S. cities it is not representative of the U.S. population. Our findings should not be extrapolated to other ages or to men. Lastly, while the prevalence analysis could be affected by reverse causation (i.e., MetS may cause inactivity), the graded association between activity and MetS suggest this is not the primary explanation: even women exercising once a week had higher odds of MetS than women exercising more often.

**Conclusions**

Childhood and adult SES predict the odds of MetS among women as they approach the menopause transition; however, adult SES (measured by education) is primarily important afterwards. Health care providers should consider patients’ SES in childhood, and especially adulthood, when assessing MetS risks. Strategies to decrease the prevalence of MetS should target the first few decades of life—specifically by reducing childhood poverty and raising educational attainment. Strategies that facilitate an active lifestyle may also be beneficial.
REFERENCES


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