



Original Contribution

Trajectories of Neighborhood Poverty and Associations With Subclinical Atherosclerosis and Associated Risk Factors

The Multi-Ethnic Study of Atherosclerosis

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The authors used data from the Multi-Ethnic Study of Atherosclerosis and latent trajectory class modeling to determine patterns of neighborhood poverty over 20 years (1980–2000 residential history questionnaires were geocoded and linked to US Census data). Using these patterns, the authors examined 1) whether trajectories of neighborhood poverty were associated with differences in the amount of subclinical atherosclerosis (common carotid intimal-media thickness) and 2) associated risk factors (body mass index, hypertension, diabetes, current smoking) at baseline (January 2000–August 2002). The authors found evidence of 5 stable trajectory groups with differing levels of neighborhood poverty (–6%, 12%, 20%, 30%, and 45%) and 1 group with 29% poverty in 1980 and approximately 11% in 2000. Mostly for women, higher cumulative neighborhood poverty was generally significantly associated with worse cardiovascular outcomes. Trends generally persisted after adjustment for adulthood socioeconomic position and race/ethnicity, although they were no longer statistically significant. Among women who had moved during the 20 years, the long-term measure had stronger associations with outcomes (except smoking) than a single, contemporaneous measure. Results indicate that cumulative 20-year exposure to neighborhood poverty is associated with greater cardiovascular risk for women. In residentially mobile populations, single-point-in-time measures underestimate long-term effects.

body mass index; carotid artery, internal; diabetes mellitus; hypertension; models, statistical; residential mobility; retrospective studies; smoking

Abbreviations: BIC, Bayesian Information Criterion; BMI, body mass index; IMT, intimal-media thickness; MESA, Multi-Ethnic Study of Atherosclerosis; SEP, socioeconomic position.

A number of studies have reported associations of neighborhood socioeconomic characteristics with cardiovascular-related outcomes that persist after statistical adjustment for individual characteristics. For example, neighborhood disadvantage has been linked to coronary heart disease prevalence, incidence, and mortality (1–6); subclinical coronary heart disease (7); and cardiovascular risk factors (3, 4, 8–11). However, almost all of these studies are based on the measurement of neighborhood characteristics at a single point in time.

Very few studies have documented what trajectories of neighborhood socioeconomic people experience in adult-

hood and how they are related to health outcomes (including cardiovascular outcomes) later in life. Because atherosclerosis develops over long periods, long-term neighborhood exposures may be more relevant to investigate than single-point-in-time exposures. Prior work has researched cumulative effects of neighborhood exposures over the life course by summing or averaging neighborhood exposures over a specified period of time (12, 13) or has estimated “independent” effects of exposures for different life epochs.

If all persons in a population stay in the same neighborhood or move between neighborhoods of a similar socioeconomic level, then an average measure and any single

measure for the specified time period would show the same association with the outcome. However, if the accumulation of neighborhood effects over the life course is affecting cardiovascular disease risk, then the use of a single-point-in-time measure may result in misestimates of area effects. Additionally, socioeconomic mobility may itself have an independent effect on cardiovascular disease health (14, 15). To test whether this is the case, cardiovascular disease health outcomes need to be compared in populations of upward- or downward-moving neighborhood poverty with what would be expected under a purely cumulative model. Prior approaches do not allow for these comparisons.

We used data from the Multi-Ethnic Study of Atherosclerosis (MESA), and latent trajectory class modeling (16, 17), to determine patterns of neighborhood poverty over a 20 year period during mid- to late adulthood. We then examined how these patterns are related to the amount of subclinical atherosclerosis as well as associated risk factors later in life. We also assessed effects of mobility by comparing cardiovascular outcomes for groups with decreased (upwardly mobile) neighborhood census tract poverty over time with groups with equivalent stable cumulative poverty. In addition, we investigated the added advantage of using a cumulative measure of neighborhood poverty compared with a single measure in adulthood.

MATERIALS AND METHODS

Study population

MESA was initiated to investigate the prevalence, correlates, and progression of subclinical cardiovascular disease. Participants were 45–84 years of age, from 6 US communities (Baltimore, Maryland; Chicago, Illinois; Forsyth County, North Carolina; Los Angeles County, California; northern Manhattan, New York; and St. Paul, Minnesota), clinically free of cardiovascular disease at baseline, and sampled to be ethnically diverse (~38% white, 28% African American, 23% Hispanic, and 11% Chinese). The methods used for sampling and study design have been reported elsewhere (18).

Assessment of neighborhoods

During one study clinic visit, participants were asked by trained interviewers to complete a 20-year residential history questionnaire (January 1980–date of visit). Each address was geocoded and assigned latitude and longitude coordinates. Census tract codes from the 1980, 1990, and 2000 US Censuses were coded to each address. For intercensal years, we interpolated the value for that year based on the 2 closest censuses. The percentage of residents living below the poverty level (i.e., neighborhood census tract poverty) for each location was obtained from the Neighborhood Change Database, which enables comparison across various census years by recalculating and normalizing past census years to 2000 US Census tract boundaries (19).

We selected neighborhood census tract poverty as our primary key neighborhood variable for the following reasons: it is often used in sociologic work to characterize

neighborhood conditions (20), it was measured in a standardized manner for all the US Censuses relevant to the period of study, and its definition is modified over time by the US Census to account for changes in the cost of living. Using this approach, we created a database that contains a measure of census tract poverty for each month between January 1980 and the date of the MESA baseline examination for each study participant. Only participants with complete address history information for the entire 20 years were included in the analyses.

Measures of long-term patterns of neighborhood poverty

Trajectory classes of neighborhood poverty over the 20 years prior to the MESA examination were identified by using hierarchical latent growth curve modeling. Individuals were assigned to trajectory classes based on their pattern of repeated measurements of annual average neighborhood poverty for each year between 1980 and 1999 (16, 17). The data trajectory for each subject consisted of repeated measurements of neighborhood census tract poverty over T time periods, $Y_i = (Y_{i1}, \dots, Y_{iT})$, that were independent given the group C_i . The trajectory was modeled as

$$\mu_{ijk} = \beta_{0k} + \text{Year}_{ij}\beta_{1k} + \text{Year}_{ij}^2\beta_{2k} + \text{Year}_{ij}^3\beta_{3k},$$

where μ_{ijk} represents the i th response of person j in group K , β_{0jk} is the estimated mean neighborhood poverty value for group k , where $\text{Year}_{ij} = 0$ (January 1980) and Year_{ij} denotes the number of years since January 1980 at subject j 's time i . Up to a third-order polynomial in year was included to flexibly model the effects of time. K numbers of groups were assigned so that the likelihood of observing the data trajectory for subject j , given that he or she belonged to group K , was estimated by using a censored normal model.

We investigated models for 2–8 trajectory groups. The number of groups selected was based on which model as a whole had the best overall Bayesian Information Criterion (BIC) value. Group membership for a given person was assigned based on which K group had the highest likelihood of observing the data trajectory observed, given that he or she belonged to group k .

In addition to categories based on trajectories of neighborhood poverty, we also investigated a measure of neighborhood percent poverty at the time of the baseline examination (referred to as the contemporaneous measure) as well as an average measure for the whole 20-year period. The average measure was the area under a continuous line fitted to each participant's data, divided by the number of months from January 1980 to the date of the baseline examination (January 2000–August 2002) (mean = 0.14, range = 0.01–0.71).

Outcome variables

Common carotid intimal-media thickness (IMT) was the measure of subclinical atherosclerosis examined. IMT is a relatively simple, inexpensive, precise, reproducible, and valid measure of early atherosclerotic changes in the carotid

artery. IMT has been shown to be associated with coronary heart disease risk factors, prevalent coronary heart disease, and subsequent coronary heart disease events (21, 22). Common carotid IMT was measured noninvasively with high-resolution B-mode ultrasonography (Logia 700 ultrasound machine; General Electric Medical Systems, Little Chalfont, Buckinghamshire, United Kingdom). Common carotid IMT reflects the mean of all available maximum wall thicknesses across all scans, across both left and right sides, and across the near and far walls. Central reading of IMT was performed at the Tufts-New England Medical Center (Boston, Massachusetts) (18).

We studied the following cardiovascular risk factors: body mass index (BMI), hypertension, diabetes, and current smoking. Low density lipoprotein cholesterol and high density lipoprotein cholesterol were also examined, but no associations were apparent for either gender, so results are not shown in this paper. BMI was calculated as weight (kg)/height (m)². Resting blood pressure was measured 3 times with a Dinamap PRO 100 automated oscillometric device (Critikon Inc., Tampa, Florida). The average of the final 2 blood pressure readings was used for this analysis. Hypertension was defined by the 6th report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (23) criteria of self-reported treatment of hypertension or systolic blood pressure of ≥ 140 mm Hg or diastolic blood pressure of ≥ 90 mm Hg. Diabetes mellitus was defined by the 2003 American Diabetes Association criteria of fasting glucose ≥ 126 mg/dL, use of insulin or oral hypoglycemic agents, or self-reported physician diagnosis. Cigarette smoking was based on self-report and was classified into 1 of 3 categories: current, former, or never (18).

Covariates

Age, gender, adult socioeconomic position (SEP), and race/ethnicity were obtained from the baseline examination interview. As in prior work (13), adult SEP was created by combining information on income, education, and wealth. Participants were asked to select their total gross family income in the past 12 months from 13 categories (collapsed into 4 for this analysis: $< \$25,000$, $\$25,000$ – $\$39,999$, $\$40,000$ – $\$74,999$, or $\geq \$75,000$). Highest educational level completed was collapsed into 4 categories: \leq high school, some college but no degree/technical school certificate, associate's or bachelor's degree, or graduate/professional degree. Wealth was assessed with the following 4 items: 1) whether the participant, or his or her family, had investments such as stocks, bonds, mutual funds, retirement investments, or other investments (yes/no); 2) whether the participant owned the home (yes/no); 3) whether the participant owned a car (yes/no); and 4) whether the participant owned land or another property that was not his or her primary residence (yes/no). A summary adult SEP score was created by summing scores for income (0–3, from lowest to highest category) and education (0–3, from lowest to highest) and adding one point for each wealth indicator present. Thus, the range of values for adult SEP was 0 to 10, with higher values indicating greater adult SEP. Race/ethnicity was clas-

sified as 1 of 4 categories: white non-Hispanic, African American non-Hispanic, Chinese, or Hispanic.

Statistical analysis

Sociodemographic characteristics and mean common carotid IMT for the chosen categories of neighborhood poverty trajectory group were compared by using analysis of variance (continuous variables) and the chi-square statistic (categorical variables). For each analysis, linear regression was used to assess mean differences in common carotid IMT and BMI, and a generalized linear model with a binomial distribution (24) was used to estimate the relative prevalence of hypertension, diabetes, and current smoking associated with the neighborhood poverty measures. These regression models were used to estimate associations of trajectory classes with the outcomes by including trajectory classes as dummy variables in the regressions. For those in stable trajectory classes, tests for trend were conducted to examine whether higher levels of neighborhood poverty were associated with worse cardiovascular outcomes.

In addition, in these same stable trajectory classes, we also contrasted associations of contemporaneous (each participant's last known address at the MESA baseline examination (January 2000–August 2002)) and average poverty with the outcomes by fitting models with each of these exposures separately and estimating the adjusted mean difference or adjusted relative prevalence of the outcome for the 90th versus the 10th percentile of each measure. The nonstable trajectory group was excluded from these analyses; because of the changing nature of poverty over time in this group, comparison of the contemporaneous and average measures is not very meaningful.

Because race/ethnicity and adult SEP may be partly confounding associations of neighborhood poverty with common carotid IMT, and associated risk factors, models were fit before and after adjustment for adult SEP and race/ethnicity. Analyses were stratified by gender because of potential differences in associations of SEP with atherosclerosis between men and women.

RESULTS

Of the total 6,814 men and women, 5,871 (86.2%) completed a residential history questionnaire at baseline (January 2000–August 2002). Of these participants, 929 (16%) were excluded because 1) one or more addresses could not be geocoded ($n = 797$) or 2) poverty values were not available for one or more of the tracts in which they had lived since January 1980 ($n = 132$); thus, data on 4,942 participants were available for analysis. Compared with persons included in the analysis, persons excluded were significantly more likely to be younger; be Chinese or Hispanic; be in the lower income or educational categories; have lower common carotid IMT, BMI, and high density lipoprotein cholesterol; and have a lower prevalence of hypertension, although differences were generally not large.

The mean age of the sample was 62.4 years; 47.6% were male; 43% were white, 30% were African American, 7% were Chinese, and 20% were Hispanic; mean BMI was 28.7

Table 1. Mean Neighborhood Poverty Trajectory Values for 1980, 1985, 1990, 1995, and 2000 for the 6 Neighborhood Trajectory Groups, Multi-Ethnic Study of Atherosclerosis, United States

	No.	%	1980	1985	1990	1995	2000
Medium high–low	204	4.1	0.29	0.27	0.14	0.10	0.11
High stable	178	3.6	0.44	0.47	0.49	0.45	0.42
Medium-high stable	470	9.5	0.31	0.33	0.34	0.33	0.31
Medium stable	806	16.2	0.20	0.21	0.22	0.24	0.24
Low-medium stable	1,116	22.7	0.12	0.13	0.15	0.15	0.15
Low stable	2,168	43.9	0.06	0.06	0.05	0.06	0.07

(standard deviation, 5.4); 46% were hypertensive; 14% were diabetic; and 13% were current smokers. The fit of the trajectory class models, as assessed by BIC value, improved from 2 classes (BIC = 110,809) through 6 classes (BIC = 148,513), but it worsened with 7 classes (BIC = 143,758). The model with 8 classes was a slightly better fit (BIC = 151,448), but zero participants were assigned to 2 of the classes, suggesting that the 6-class model was the best fit for the data (Table 1).

Participants in the low stable poverty group were significantly more likely to be male, white, and US born. These participants had the most favorable risk factor profiles of all of the groups: the lowest mean BMI and the lowest prevalence of hypertension, diabetes, and current smoking. Moving from the lowest stable group to the highest stable group, the groups were younger, included more females, included fewer whites or Chinese, included more blacks and Hispanics (with a decrease in Hispanics and an increase in blacks in the highest poverty group), were less likely to be US born, and had a higher mean BMI and a higher prevalence of hypertension, diabetes, and current smoking. The percentage of persons who moved over the 20 years decreased monotonically from a high of 56% in the low stable poverty group to a low of 42% in the high stable poverty group (Table 2).

Only one group with a changing (i.e., not stable) neighborhood poverty trajectory was identified. This group (labeled medium high–low) began the period at a medium-high neighborhood poverty level (mean, 29%) and experienced a decline in neighborhood poverty over time (mean, 11%) (Table 1). The medium high–low group was the youngest and most female. The racial/ethnic distribution was similar to that of the medium stable group except for a larger representation of Chinese. This group, compared with the other groups, also had the lowest mean common carotid IMT, a relatively low prevalence of diabetes, and a high prevalence of current smokers. Virtually all (96%) persons in this group moved at some point over the 20-year period (Table 2).

Among women, there was clear evidence that, after age adjustment, groups experiencing higher stable neighborhood census tract poverty over time had a higher common carotid IMT and BMI and more diabetes and hypertension than those in the low stable poverty group. For men, this finding was true for only diabetes—with less clear patterns.

For both genders, after adjustment for race and adult SEP, only the medium-high stable group for BMI and the medium-high and high stable groups for diabetes in women had mean outcomes significantly higher than those in the low stable group. However, point estimates showed that a general trend of greater common carotid IMT, greater BMI (except for the highest poverty category), and greater prevalence of diabetes and hypertension associated with higher levels of neighborhood poverty tended to persist after adjustment, although the trends were no longer statistically significant at the 0.05 level (Figures 1–4). For men and women, stable poverty trajectory groups above the low stable group had a higher prevalence of current smoking, but a dose-response relation was not apparent (Figure 5). When we adjusted for adult SEP, results were similar when the individual SEP components of the composite score were adjusted for rather than the composite score (data not shown).

With few exceptions, cardiovascular outcomes for the medium high–low trajectory group (category shown to the right of the stable groups in each figure) were somewhere in between those for the low-medium stable and medium stable groups (which averaged 12% and 20% neighborhood poverty levels, respectively, comparable to the medium high–low group's average of 18.5%). For men, mean common carotid IMT was lower (Figure 1) and the prevalence of hypertension was nonsignificantly higher (Figure 3) in the medium high–low group than in any of the other trajectory groups. Residential mobility over the 20 years was not associated with any of the outcomes after adjustment for age, cumulative neighborhood poverty, and race/ethnicity (data not shown).

For all outcomes except smoking, associations using the contemporaneous or average poverty measure were similar for women reporting 1 address. However, for women reporting 2 or more addresses, associations were consistently stronger when the average poverty measure was used. In contrast, for current smoking, among women with 2 or more addresses, associations were stronger for the contemporaneous measure than for the average measure. There was no clear pattern for men. These analyses were restricted to the stable trajectory groups (Table 3).

DISCUSSION

We found evidence of several different subpopulations of neighborhood trajectory groups, with most groups experiencing approximately stable neighborhood poverty over the entire time period but differing in level of neighborhood poverty. For women, higher cumulative neighborhood poverty was generally significantly associated with worse cardiovascular outcomes in age-adjusted models, and, whereas the general trends (as indicated by the point estimates) tended to persist after adjustment for adult SEP and race/ethnicity, confidence intervals for many of the estimates were wide and trends were no longer statistically significant. No consistent association of neighborhood poverty with the outcomes was observed for men. In general, the medium high–low neighborhood poverty mobility group had outcomes comparable to those for stable groups with similar

Table 2. Sociodemographic Characteristics by Neighborhood Trajectory Class, Multi-Ethnic Study of Atherosclerosis, United States, 2000–2002^a

	Low Stable (n = 2,168)		Low-Medium Stable (n = 1,116)		Medium Stable (n = 806)		Medium-High Stable (n = 470)		High Stable (n = 178)		Medium High–Low (n = 204)	
	Mean (SD)	%	Mean (SD)	%	Mean (SD)	%	Mean (SD)	%	Mean (SD)	%	Mean (SD)	%
Baseline neighborhood poverty ^{b,c}	0.06 (0.04)		0.12 (0.05)		0.20 (0.07)		0.31 (0.08)		0.44 (0.10)		0.29 (0.11)	
20-Year average neighborhood poverty ^{b,c}	0.06 (0.02)		0.14 (0.02)		0.22 (0.03)		0.33 (0.03)		0.45 (0.06)		0.18 (0.05)	
Age, years ^b	62.8 (9.7)		61.9 (10.2)		63.5 (10.3)		62.4 (10.4)		60.1 (9.0)		59.1 (10.3)	
Male ^b		50		47		46		45		42		41
Moved during the last 20 years ^b		56		52		46		40		37		96
No. of moves ^b	2.1 (1.7)		2.1 (1.5)		1.9 (1.4)		1.7 (1.2)		1.6 (1.0)		3.1 (1.5)	
Race ^b												
White non-Hispanic		63		44		21		7		5		24
Chinese		8		5		6		3		0		12
African-American non-Hispanic		19		31		43		47		62		39
Hispanic		10		19		31		43		33		25
US born ^{b,d}		85		82		71		55		57		69
Married at baseline ^b		69		57		51		46		48		51
Body mass index, kg/m ^{2b}	28.1 (5.2)		28.5 (5.3)		29.4 (5.7)		29.6 (6.0)		30.0 (5.5)		29.2 (5.5)	
LDL cholesterol, mg/dL	117.4 (29.9)		117.1 (32.0)		117.7 (33.5)		116.5 (31.7)		116.2 (31.0)		118.7 (33.1)	
HDL cholesterol, mg/dL	51.5 (15.1)		51.6 (15.0)		50.2 (14.9)		51.1 (13.5)		51.1 (15.3)		49.4 (13.1)	
CIMT, μ m	872.5 (195.2)		870.9 (189.6)		893.2 (183.6)		885.7 (199.5)		879.2 (193.5)		833.2 (166.7)	
Hypertension ^b		44		44		51		52		54		46
Diabetes ^b		9		13		15		17		24		11
Current cigarette smoker ^b		10		14		15		16		19		17

Abbreviations: CIMT, common carotid intimal-media thickness; HDL, high density lipoprotein; LDL, low density lipoprotein; SD, standard deviation.

^a Neighborhood poverty from January 1980 to 2000: ~6% all = low stable; ~12% all = low-medium stable; ~20% all = medium stable; ~31% all = medium-high stable; ~45% all = high stable; ~30% to ~10% = medium-high–low.

^b Test for trend significant at the 0.05 level.

^c The value 0.06, for example, indicates that the mean number of households in that census block living below the poverty line is 6/100.

^d All participants have been in the United States since January 1980.

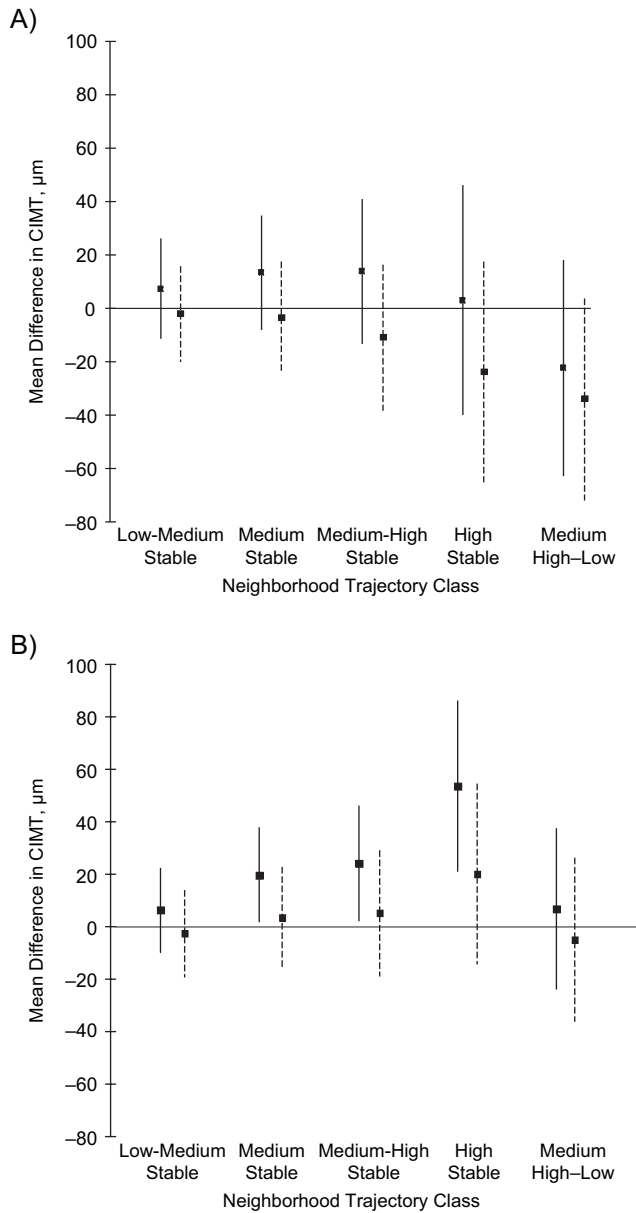


Figure 1. Adjusted mean differences in common carotid intima-media thickness (CIMT) (μm), and 95% confidence intervals, for neighborhood trajectory classes compared with the low stable group for A) males and B) females. Solid vertical line: age adjusted; dotted vertical line: age–adult socioeconomic position and race adjusted. *P* for trend (stable groups only)—age adjusted: A) 0.2362, B) 0.0002; age–adult socioeconomic position and race adjusted: A) 0.3451, B) 0.2568.

cumulative exposures. In addition, for women who moved, the long-term average measure of poverty was more strongly associated with outcomes than a single, contemporaneous measure. In contrast, the opposite was true for current smoking.

Few prior studies have investigated trajectories of neighborhood poverty over time. In our sample, the relative stability of residence over the study period (47% did not move during the entire 20 years), coupled with very few changes

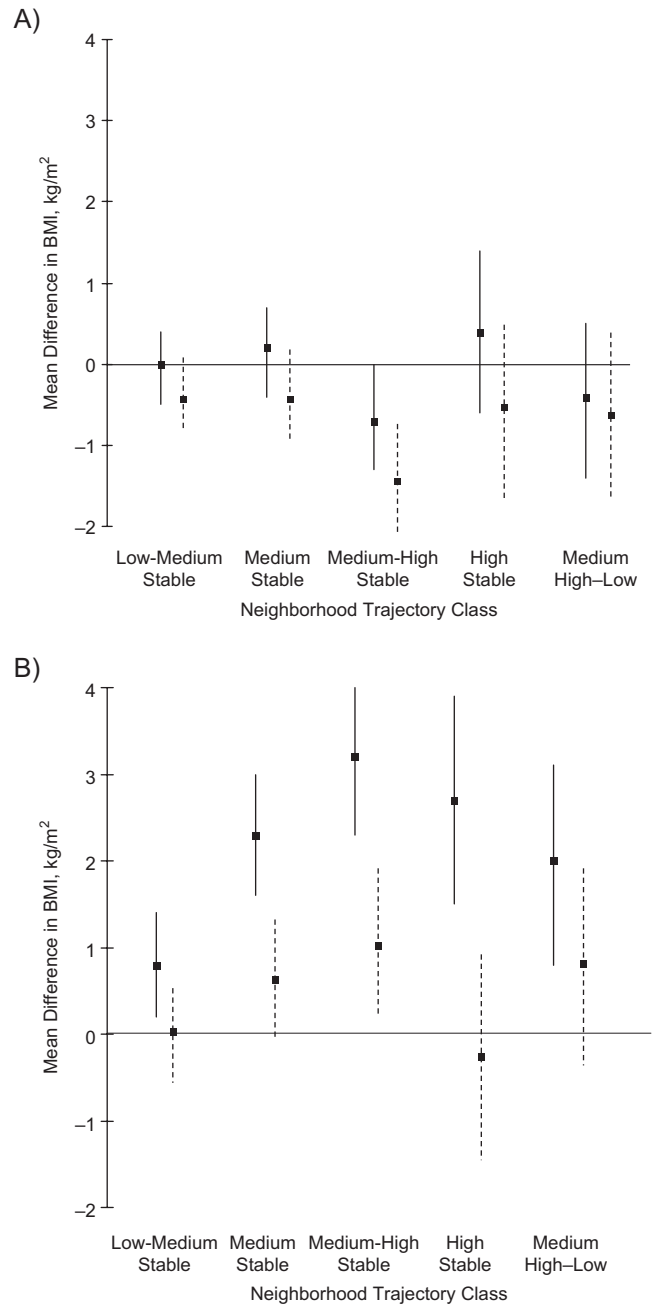


Figure 2. Adjusted mean differences in body mass index (BMI), and 95% confidence intervals, for neighborhood trajectory classes compared with the low stable group for A) males and B) females. Solid vertical line: age adjusted; dotted vertical line: age–adult socioeconomic position and race adjusted. *P* for trend (stable groups only)—age adjusted: A) 0.6932, B) <0.001; age–adult socioeconomic position and race adjusted: A) 0.0022, B) 0.1043.

in poverty within census tracts over time, resulted in stable trajectory groups. However, almost 50% of the stable groups had moved at least once, and correlations between poverty levels in subsequent neighborhoods were positive although not very high (Pearson’s correlations of neighborhood poverty between each pre- and postmove neighborhood, 0.36).

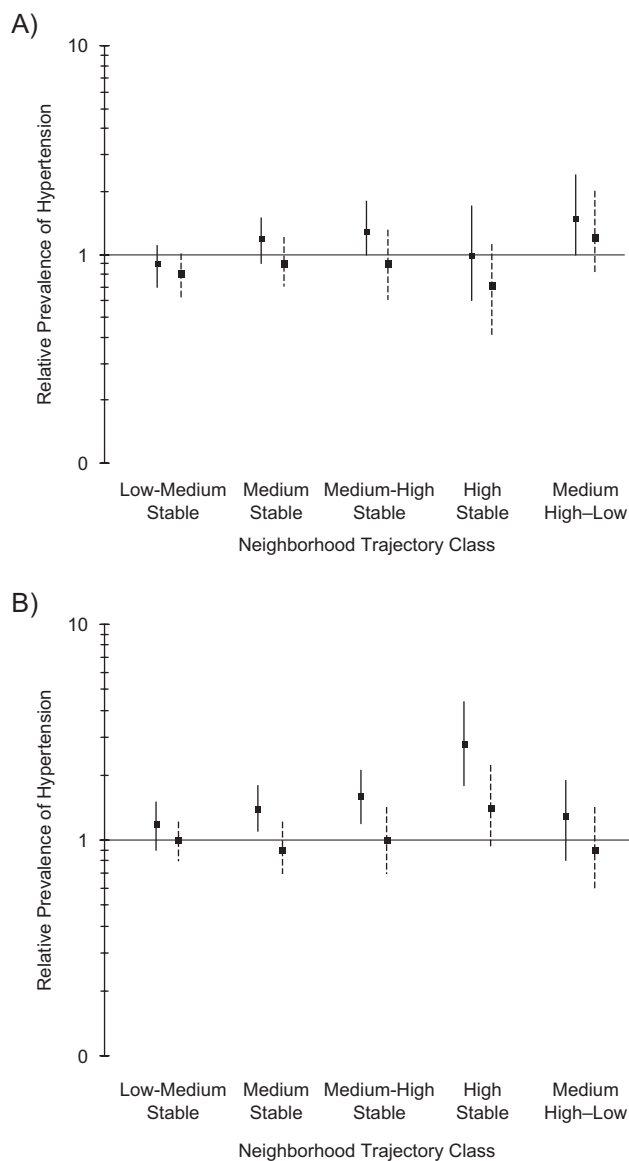


Figure 3. Adjusted relative prevalences of hypertension, and 95% confidence intervals, for neighborhood trajectory classes compared with the low stable group for A) males and B) females. Solid vertical line: age adjusted; dotted vertical line: age–adult socioeconomic position and race adjusted. *P* for trend (stable groups only)—age adjusted: A) 0.0962, B) <0.001; age–adult socioeconomic position and race adjusted: A) 0.1925, B) 0.5045.

In general, our sample was less mobile than the US population of the same age (percentage who moved at least once between 1995 and 2000: US Census, 33.1%; MESA, 16.7%). The peak age for mobility is 20–29 years, with mobility decreasing with age (25). Consequently, the relative residential stability of our sample may be attributable to its age (41% were older than age 65 years) or to selection effects related to participation in a long-term study such as MESA.

These results are consistent with prior analyses of other cohorts showing that cumulative neighborhood SEP is asso-

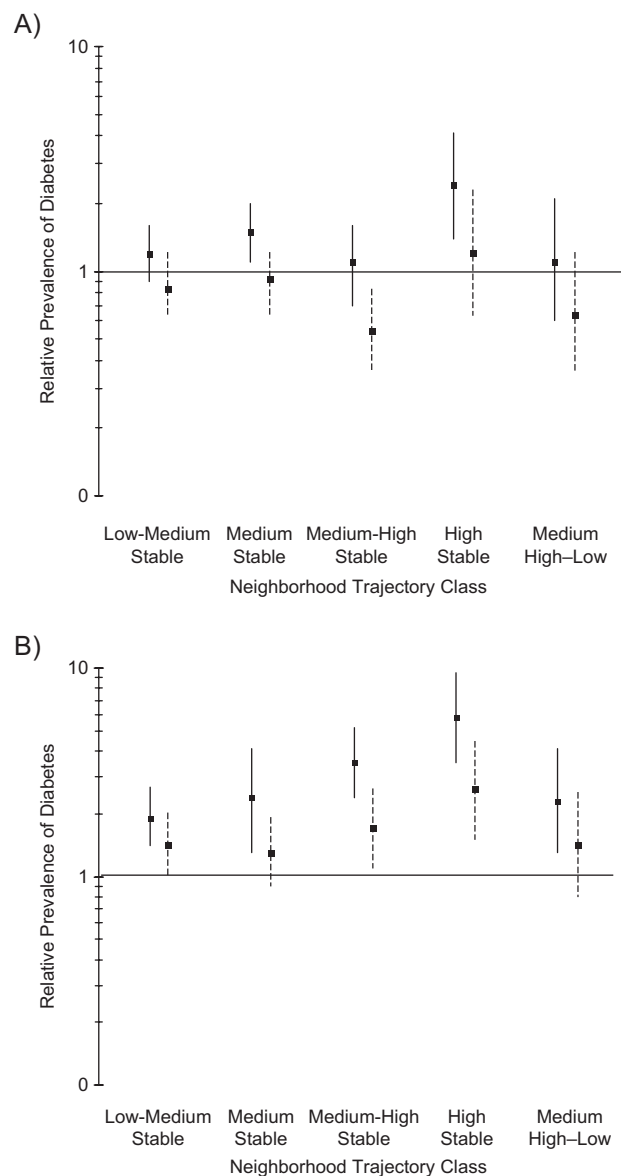


Figure 4. Adjusted relative prevalences, and 95% confidence intervals, of diabetes for neighborhood trajectory classes compared with the low stable group for A) males and B) females. Solid vertical line: age adjusted; dotted vertical line: age–adult socioeconomic position and race adjusted. *P* for trend (stable groups only)—age adjusted: A) 0.0055, B) <0.0001; age–adult socioeconomic position and race adjusted: A) 0.4063, B) 0.0012.

ciated with higher mean common carotid IMT in white women (12), with patterns still apparent but nonsignificant after adjustment for individual SEP and race/ethnicity (12, 13). The measures of neighborhood SEP used in previous work were summaries or average measures of neighborhood socioeconomic status. In contrast, we examined distinct trajectories of neighborhood poverty over time. Potential mechanisms linking long-term neighborhood conditions to cardiovascular disease include access to resources and services that promote healthy lifestyles, as well as social

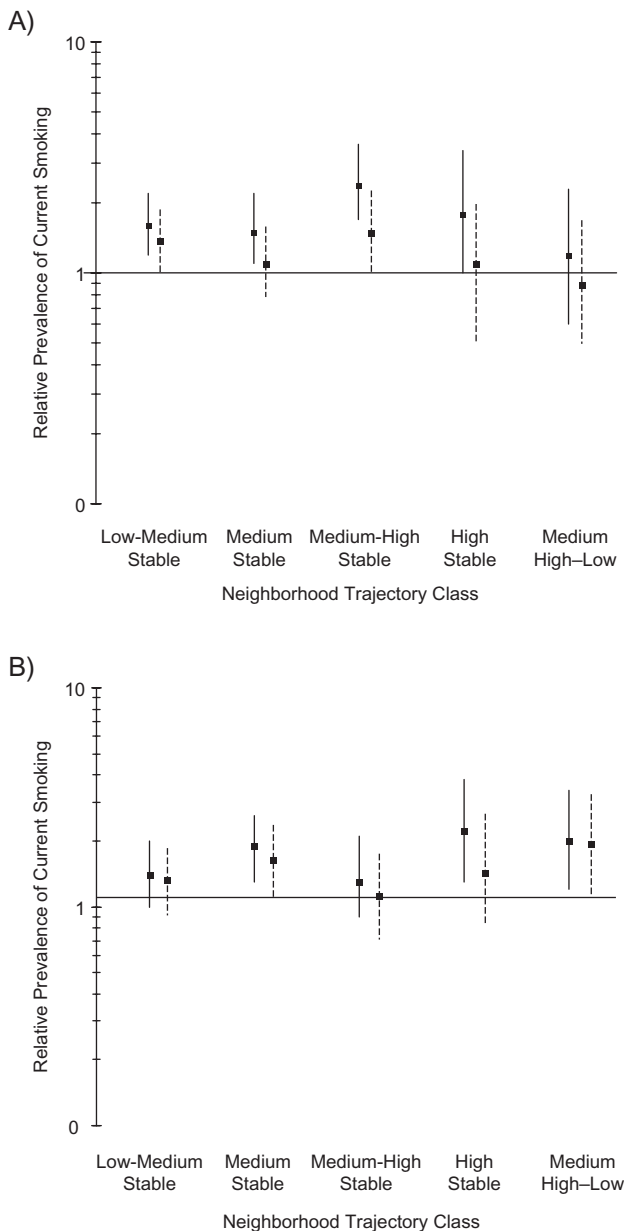


Figure 5. Adjusted relative prevalences, and 95% confidence intervals, of current smoking for neighborhood trajectory classes compared with the low stable group for A) males and B) females. Solid vertical line: age adjusted; dotted vertical line: age–adult socioeconomic position and race adjusted. *P* for trend (stable groups only)—age adjusted: A) <0.0001, B) 0.0008; age–adult socioeconomic position and race adjusted: A) 0.1904, B) 0.2246.

features such as social norms, social support, and features of neighborhoods (such as violence or disorder) that could be stressful (2). To the extent that neighborhood poverty is a reasonable proxy for these conditions, our results may reflect cumulative effects of these exposures.

Few data exist on how fluctuations in neighborhood poverty over time could translate into better or worse cardio-

vascular disease risk factors and outcomes for residents. It is plausible that changes in neighborhood poverty are associated with changes in specific environmental features linked to cardiovascular disease. For instance, some studies have found that lower income neighborhoods have fewer supermarkets and more fast-food restaurants than wealthier neighborhoods do (26). Persons moving from higher to lower income neighborhoods or experiencing a change in the socioeconomic features of their neighborhoods over time could also be exposed to changes in food environments related to cardiovascular disease. Measuring neighborhood poverty at a single point in time would give an incomplete assessment of what neighborhood exposures an individual had experienced over that time period and could therefore lead to underestimates of neighborhood effects.

Consistent with our results, previous literature has documented a stronger effect of neighborhood deprivation on the incidence and prevalence of coronary heart disease in women than men (1, 3, 27). A number of processes could explain the stronger associations among women, including greater exposure to neighborhood conditions or greater reliance on neighborhood resources for women than for men (13). Further study is needed to examine mechanisms related to heterogeneity of neighborhood effects by gender. We found that most associations of neighborhood poverty with the cardiovascular disease risk factors were attenuated after adjustment for adult SEP and race/ethnicity. General patterns tended to remain, although trend tests were no longer statistically significant. The strong association of trajectories of neighborhood poverty with adult SEP and race/ethnicity in these data makes it difficult to isolate their “independent” contributions. In addition, adult SEP may be partly influenced by a history of exposure to neighborhood poverty. Statistical controls for race/ethnicity and adult SEP may therefore result in underestimates of neighborhood effects.

One group, the medium high–low group, displayed a substantial change in neighborhood poverty over the period (dropping from 29% to 11%). This change was largely attributable to residential mobility (96% had moved over the period, and Pearson’s correlations between census years for all census tracts in the Neighborhood Change Database were very high (1980–2000: 0.73, 1980–1990: 0.76, 1990–2000: 0.85). Our results with respect to cardiovascular outcomes in this group support an accumulation model of neighborhood exposure to poverty with little evidence of an independent effect of social mobility (15, 28). However, our ability to examine this trajectory group was limited by small sample size ($n = 204$ or 4.1% of the sample). Further study is needed to examine whether residential mobility patterns in MESA are representative of patterns of moving during mid- to late adulthood.

The finding that 96% of the sample was classified into a “stable” trajectory group implies that a contemporaneous single-point-in-time measure of neighborhood poverty may accurately represent past neighborhood exposure. However, we found that, even in the “stable” trajectory groups, when women had moved during the historical period of interest, use of the long-term average measure of exposure rather than a contemporaneously measured exposure resulted in

Table 3. Mean Differences in CIMT and Body Mass Index, and Relative Prevalences of Hypertension, Diabetes, and Current Smoking, for the 90th vs. 10th Percentile of Contemporaneous^a and Average Neighborhood Poverty During a 20-Year Period (1980–2000) for Women With Stable Trajectories (*n* = 2,592), Multi-Ethnic Study of Atherosclerosis, United States

Outcome and Adjustment	Women Reporting Only 1 Address (<i>n</i> = 1,245)				Women Reporting ≥2 Addresses (<i>n</i> = 1,347)			
	Contemporaneous		Average		Contemporaneous		Average	
	Mean Difference	95% CI	Mean Difference	95% CI	Mean Difference	95% CI	Mean Difference	95% CI
CIMT (<i>n</i> = 2,561)								
Age	31.8	11.0, 52.5	28.9	8.2, 49.6	18.5	−2.3, 39.3	35.4	12.5, 58.4
Age and adult SEP	32.3	10.4, 54.2	29.1	7.3, 50.9	8.1	−13.9, 30.1	25.3	1.0, 49.7
Age, adult SEP, and race/ethnicity	28.7	4.5, 52.9	25.0	1.0, 48.9	−14.2	−37.3, 8.9	−2.6	−29.1, 23.9
Body mass index (<i>n</i> = 2,592)								
Age	2.4	1.7, 3.2	2.3	1.6, 3.1	2.5	1.7, 3.3	3.4	2.5, 4.2
Age and adult SEP	2.1	1.3, 2.9	2.0	1.2, 2.8	1.8	1.0, 2.7	2.7	1.7, 3.6
Age, adult SEP, and race/ethnicity	0.8	−0.1, 1.6	0.7	−0.2, 1.5	0.1	−0.8, 0.9	0.4	−0.6, 1.4
	Relative Prevalence	95% CI	Relative Prevalence	95% CI	Relative Prevalence	95% CI	Relative Prevalence	95% CI
Hypertension (<i>n</i> = 2,592)								
Age	1.7	1.5, 2.0	1.6	1.4, 1.9	1.5	1.2, 1.8	2.0	1.6, 2.3
Age and adult SEP	1.7	1.4, 2.0	1.6	1.3, 1.9	1.3	1.0, 1.6	1.7	1.4, 2.0
Age, adult SEP, and race/ethnicity	1.2	0.9, 1.5	1.1	0.8, 1.4	0.9	0.5, 1.2	1.0	0.7, 1.4
Diabetes (<i>n</i> = 2,582)								
Age	2.2	1.8, 2.6	2.4	2.0, 2.8	2.7	2.3, 3.1	3.7	3.3, 4.1
Age and adult SEP	1.9	1.5, 2.3	2.1	1.7, 2.5	2.1	1.7, 2.5	2.9	2.4, 3.3
Age, adult SEP, adult and race/ethnicity	1.2	0.7, 1.6	1.3	0.9, 1.8	1.5	1.0, 1.9	1.9	1.4, 2.3
Current smoking (<i>n</i> = 2,584)								
Age	2.3	1.7, 2.7	2.1	1.7, 2.5	1.8	1.4, 2.1	1.4	1.0, 1.8
Age and adult SEP	2.1	1.7, 2.5	1.9	1.5, 2.3	1.5	1.1, 1.9	1.2	0.7, 1.6
Age, adult SEP, and race/ethnicity	2.2	1.7, 2.7	2.0	1.5, 2.4	1.3	0.9, 1.7	0.9	0.4, 1.4

Abbreviations: CI, confidence interval; CIMT, common carotid intimal-media thickness; SEP socioeconomic position.

^a Contemporaneous refers to each participant's address at the baseline Multi-Ethnic Study of Atherosclerosis examination (January 2000–August 2002).

stronger associations with health outcomes that develop over long periods (such as subclinical atherosclerosis). In contrast, a current behavior such as smoking was more strongly related to current conditions than to past conditions. These results suggest that, when estimating long-term exposures in the presence of residential mobility, reliance on a single-point-in-time measure could lead to underestimates of the effects of cumulative long-term exposures to neighborhood conditions.

Limitations of our study include limited trajectory groups in which neighborhood poverty changed substantially over time and retrospective collection of residential history information, which could have resulted in important misclassification of poverty exposures. The exposure to neighborhood was measured with only a single indicator,

neighborhood census tract poverty, and captured only 20 years of exposure in late adulthood. Census tracts may not be the most relevant geographic unit, 20 years may not fully capture the historical time frame relevant to the outcomes we studied, and the 20 years might be capturing a different period in adulthood depending on the participant's age when he or she entered the study.

Our results indicate that a summary of 20-year exposure to neighborhood poverty is associated with greater cardiovascular risk for women. They also suggest that, in many cases, single-point-in-time measures may be reasonable proxies for historical exposures, although they may underestimate neighborhood effects in the presence of important residential mobility and for outcomes that develop over long periods.

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