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Authors
Powell-Wiley, Tiffany M
Moore, Kari
Allen, Norrina
et al.

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Original Contribution

Associations of Neighborhood Crime and Safety and With Changes in Body Mass Index and Waist Circumference

The Multi-Ethnic Study of Atherosclerosis

Tiffany M. Powell-Wiley*, Kari Moore, Norrina Allen, Richard Block, Kelly R. Evenson, Mahasin Mujahid, and Ana V. Diez Roux

* Correspondence to Dr. Tiffany M. Powell-Wiley, Cardiovascular and Pulmonary Branch, Division of Intramural Research, National Heart, Lung, and Blood Institute, National Institutes of Health, Building 10-CRC, Room 5-3340, Bethesda, Maryland, 20892 (e-mail: tiffany.powell-wiley@nih.gov).

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Using data from the Multi-Ethnic Study of Atherosclerosis (MESA), we evaluated associations of neighborhood crime and safety with changes in adiposity (body mass index (BMI) and waist circumference). MESA is a longitudinal study of cardiovascular disease among adults aged 45–84 years at baseline in 2000–2002, from 6 US sites, with follow-up for MESA participants until 2012. Data for this study were limited to Chicago, Illinois, participants in the MESA Neighborhood Ancillary Study, for whom police-recorded crime data were available, and who had complete baseline data ($n = 673$). We estimated associations of individual-level safety, aggregated neighborhood-level safety, and police-recorded crime with baseline levels and trajectories of BMI and waist circumference over time using linear mixed modeling with random effects. We also estimated how changes in these factors related to changes in BMI and waist circumference using econometric fixed-effects models. At baseline, greater individual-level safety was associated with more adiposity. Increasing individual- and neighborhood-level safety over time were associated with decreasing BMI over the 10-year period, with a more pronounced effect observed in women for individual-level safety and men for neighborhood-level safety. Police-recorded crime was not associated with adiposity. Neighborhood-level safety likely influences adiposity change and subsequent cardiovascular risk in multiethnic populations.

adiposity; crime; environment; neighborhood; obesity; safety

Abbreviations: BMI, body mass index; MESA, Multi-Ethnic Study of Atherosclerosis; SE, standard error.

The high prevalence of obesity and overweight in the United States has been well documented (1, 2), and neighborhood crime and perceived safety have been examined in relation to body mass index (BMI) and obesity. Various studies have shown that living in neighborhoods with higher police-reported crime is associated with higher BMI and obesity levels over the life course (3–12). Self-reported safety assessments indicate that lower perceived neighborhood safety is associated with higher BMI and obesity (13–15). This relationship has also been found when neighborhood-level safety measures are created by aggregating reports from different individuals (16, 17). However, prior studies evaluating the relationship between police-reported crime or perceived safety and adiposity have been limited to cross-sectional analyses only. While some cross-sectional studies have examined US-based cohorts (10, 11, 18), many have focused on cohorts outside of the United States (3, 4, 6, 7, 13), limiting generalizability to US populations. Moreover, many studies have relied on self-reported rather than measured weight and height in determining adiposity or have not included waist circumference (3–7, 13, 16, 17). Waist circumference may better indicate cardiovascular risk (19) and may be more closely linked to stress-related mechanisms

(20) hypothesized to be involved in the relationship between neighborhood safety and cardiovascular disease.

Although prior work examined the associations of crime and perceived safety with changes in BMI over time in children and adolescents (21, 22), these relationships have not been explored in adult populations. To our knowledge, there are no studies assessing whether crime and safety changes over time are associated with BMI or waist circumference changes. The availability of data on both police-recorded crime and neighborhood-safety perceptions in the Multi-Ethnic Study of Atherosclerosis (MESA) Neighborhood Ancillary Study allowed the opportunity to examine these relationships. We hypothesized that persons living in areas with higher rates of crime and lower safety would have higher baseline BMI and waist circumference. Additionally, we hypothesized that those living with a greater crime increase and greater safety decrease over time would experience greater increases in BMI and waist circumference. As a secondary aim, we explored whether these patterns differed by sex, because studies have suggested that associations of neighborhood characteristics with outcomes may do so (3, 7, 23).

METHODS

Study sample

MESA is a longitudinal study of cardiovascular disease among adults aged 45–84 years at 6 US sites (Forsyth County, North Carolina; New York, New York; Baltimore, Maryland; St. Paul, Minnesota; Chicago, Illinois; and Los Angeles, California). Persons with a history of clinically overt cardiovascular disease were excluded. The study recruited 6,814 participants at baseline (examination 1), during July 2000 to July 2002, with follow-up examinations occurring during July 2002 to January 2004 (examination 2), January 2004 to September 2005 (examination 3), September 2005 to June 2007 (examination 4), and April 2010 to February 2012 (examination 5) (24). The study was approved by each site's institutional review board, and all participants gave written informed consent. Our sample was restricted to those who participated in the MESA Neighborhood Ancillary Study with geocoding accuracy of street-level or zip+4 centroid, were within Chicago city limits, and had all measures available ($n = 673$ at examination 1), because police-recorded crime measures were available only from this MESA site. Addresses were geocoded using Tele Atlas EZ-Locate web-based software (Tele Atlas North America, Lebanon, New Hampshire) (25).

Outcomes

Outcomes of interest were BMI and waist circumference measured at examinations 1–5. Weight and height were measured using a balance-beam scale and stadiometer, respectively, and used to calculate BMI as weight (kilograms) divided by height (meters) squared. Waist circumference was measured at the minimum abdominal girth using a steel measuring tape of standard 4-ounce tension in centimeters. Both measures were modeled as continuous variables.

Safety

Perceived safety was collected from a questionnaire administered to participants in 2003–2005 (in examination 2 or 3) and 2010–2012 (examination 5). Participants responded on a 5-point scale ranging from "strongly agree" (1) to "strongly disagree" (5) regarding feeling safe walking in their neighborhood day or night and violence being a problem in their neighborhood. Neighborhood was defined as the area within a 20-minute walk (about a mile) from home. The mean of these responses (with the walking-safety item reverse-coded) generated the individual-level safety measure, ranging from 1 to 5, with a higher value indicating higher perceived safety. Questions similar to these had acceptable test-retest reliability in other urban populations (26, 27).

In addition to individual-level safety perceptions (henceforth termed "individual-level safety"), we created summary measures for each neighborhood based on aggregating perceptions of multiple neighborhood residents. Although these measures are individually based on perceptions, the aggregation process averaged out individual subjectivities to yield what is hypothesized to be a more valid estimate of the underlying objective neighborhood construct (27, 28). This construct is henceforth termed "neighborhood-level safety." To create neighborhood measures, we pooled MESA respondents' data together with identical data collected from samples of neighborhood residents from June to August of 2004 and May 2011 to May 2012. Neighborhood residents' data were used to reduce same-source bias. Summary measures for census tracts were created using empirical Bayesian estimation as previously described, adjusting for respondents' age and sex (27). Neighborhood-level safety measures were linked to MESA participants by geocoded census-tract identification. For study years in which individual-level and neighborhood-level safety measurements were unavailable, the measurements were imputed with the value at the time point closest to each examination date. Both measures were modeled as continuous variables.

Police-recorded crime

Police-recorded crime data for years 2001–2012 were from the City of Chicago Data Portal, which houses data on crime occurring within the Chicago, Illinois, city limits (29), including crime location geocoded to 100th block (1/8 mile) centerlines, date, and crime type. For the years 1999–2000, police-recorded crime data were obtained from the Chicago Police Department that were similar to data available from the portal. Crime types were categorized as assault/battery, criminal offenses (robbery, sexual assault, weapons), incivilities (drugs, prostitution, vandalism), and homicide, as described previously (30). Crimes in which the location description indicated that it occurred at an airport or on an airplane were excluded. Measures for the total number of incidents within each crime category within 1 mile around participants' addresses were created using ArcGIS, version 9.1 (ESRI, Redlands, California). We created normalized 1-year crime rates (31), in which the numerator was the sum of crime counts within the buffer over the previous year prior to the exam date. The denominator was the total buffer population, which was calculated based on block-level census population.

Each block was weighted by the percentage of the block area that fell within the participant buffer. The total population within that block was multiplied by this weight, and weighted populations were summed for the total population within the buffer. For dates prior to January 2006 (the midpoint between 2000 and 2010), population counts were obtained from US Census 2000. For dates in or after January 2006, population counts were obtained from US Census 2010. Rates were multiplied by 1,000 for a crime rate per 1,000 persons. Analyses shown are only for total crime. Analyses for the separate crime categories, including violent crime, gave similar results to those observed for total crime. Crime was modeled as a continuous variable.

Covariates

Time-invariant sociodemographic variables (age, sex, race/ethnicity, education, and neighborhood residence duration in years) were obtained through self-report at examination 1. Race/ethnicity was categorized as white, black, or Chinese-American. No Hispanic participants were recruited at the Chicago site. Education was categorized by highest level completed: up to high school or equivalent, some college, and bachelor's degree or higher. Time-varying covariates, including smoking status, household income, physical activity, and total calorie intake, were assessed at examination 1 and follow-up examinations. Smoking status was reported as never smoked, former smoker, and current smoking (within the last 30 days). Household income was categorized in dollars as <40,000, 40,000–75,000, and, ≥75,000. Physical activity was obtained from an interviewer-administered questionnaire adapted from the Cross-Cultural Activity Participation Study (32, 33) and measured as moderate to vigorous physical activity in metabolic equivalent minutes per week, as previously reported (34). Household income and physical activity were assessed only at examinations 1–3 and 5; examination 4 values were imputed with information from either examination 3 or examination 5, depending on which was closer in time. Total calorie intake was assessed at examinations 1 and 5 with a food frequency questionnaire (35), and values for examinations 2–4 were imputed using the information closest in time. Moving status was defined as whether participants had moved in the time period since the previous exam, based on reported address change. Neighborhood-level socioeconomic status was measured by a factor score as described elsewhere (36). Data from US Census 2000 were used for examination years 2000–2004 (37), American Community Survey 2005–2009 estimates for years 2005–2007 (38), and American Community Survey 2007–2011 estimates for years 2008–2012 (39).

Statistical analyses

Descriptive analyses compared participant characteristics, BMI, waist circumference, individual-level safety, neighborhood-level safety, and police-recorded crime across the 5 examinations. We also described average 10-year changes based on unadjusted linear regression models.

To test for cross-sectional associations at baseline, as well as associations of cumulative exposure to safety and crime with BMI and waist circumference trajectory over time during the follow-up period, we used linear mixed models with random intercepts and time slopes across individuals. Cumulative exposure was defined as the monthly average from baseline to time of each exam. We modeled repeated BMI and waist circumference measures for each participant as a function of safety/crime at baseline, time since baseline, an interaction between cumulative average of safety/crime and time (trajectory of BMI/waist circumference by cumulative exposure to safety/crime levels), time-invariant covariates (baseline age, sex, race/ethnicity, education, and neighborhood residence duration), all time-invariant covariates with time interaction to account for difference in trajectories by covariates, and time-varying covariates (household income, physical activity, smoking status, total calorie intake, moving status, and neighborhood-level socioeconomic status).

To test the association of change in safety and police-recorded crime with change in BMI and waist circumference, we used econometric fixed-effects models. This approach estimates associations between exposures and outcomes using only within-person variability. In so doing, it allows examination of how within-person change in the exposure is related to within-person change in the outcome after tightly controlling for person-specific characteristics (40). All models were adjusted for time since baseline, interactions of time-invariant variables with time (age at baseline, sex, race/ethnicity, and neighborhood residence duration), and time-varying covariates (household income, physical activity in quartiles, smoking status, total calorie intake, moving status, and neighborhood-level socioeconomic status).

For both mixed models and fixed-effects analyses described above, each safety and crime measure was first tested individually. To test differences by sex, we included interactions between safety and crime measures with sex. Because the interactions were statistically significant for neighborhood-level safety (P for interaction < 0.05), we fitted all models for the overall population and stratified by sex. In addition, neighborhood-level safety and crime models were analyzed by adding individual-level safety to test whether the effect changed.

RESULTS

The population was followed 9.4 (standard deviation, 0.5) years on average (Table 1). At baseline, the population was 56% non-Hispanic white, 31% non-Hispanic black, and 14% non-Hispanic Chinese; there were no significant differences in the population distribution by race/ethnicity, sex, or individual-level and neighborhood-level socioeconomic status across examination periods (Table 1). Spearman correlation coefficients for individual-level and neighborhood-level safety, individual-level safety and total crime, and neighborhood-level safety and total crime were 0.55, −0.18, and −0.22, respectively. Neighborhood-level safety decreased from baseline to examination 5 (10-year change = −0.12 (standard error (SE), 0.01) units; $P < 0.05$) while total crimes decreased by 21.6 (SE, 1.4) incidents per 1,000 persons ($P < 0.05$). Mean BMI did not change significantly, but mean waist circumference increased by 1.6 (SE, 0.4) cm ($P < 0.05$) from baseline to examination 5.

Table 1. Selected Characteristics of Participants at Baseline and Follow-up Examinations, Multi-Ethnic Study of Atherosclerosis, Chicago, Illinois, 2000–2012

Characteristic	Baseline ($n = 673$)		Examination 2 ($n = 641$)		Examination 3 ($n = 586$)		Examination 4 ($n = 463$)		Examination 5 ($n = 426$)		10 Year Change (SE)[a]
	%	Mean (SD)	%	Mean (SD)	%	Mean (SD)	%	Mean (SD)	%	Mean (SD)	
Time elapsed since baseline				1.6 (0.3)		3.1 (0.3)		4.7 (0.3)		9.4 (0.5)	
Age, years		62.3 (9.8)		63.8 (9.7)		65.4 (10.0)		66.2 (9.6)		70.5 (9.6)	10.0 (0.02)[b]
Men, %	45.9		45.9		44.2		44.1		43.2		
Race/ethnicity, %											
Non-Hispanic white	55.6		56.3		56.7		56.8		54.5		
Non-Hispanic black	30.6		30.0		29.5		27.7		29.8		
Non-Hispanic Chinese	13.8		13.7		13.8		15.6		15.7		
Education, %											
High school/GED or less	14.1		14.2		14.2		13.4		13.2		
Some college	24.1		23.4		21.7		21.4		21.4		
Bachelor degree or above	61.8		62.4		64.2		65.2		65.5		
Household income in $, %											
<40,000	27.5		28.1		29.4		26.6		28.2		
40,000–74,999	24.8		24.5		24.2		24.6		25.1		
75,000+	47.7		47.4		46.4		48.8		46.7		
Smoking status, %											
Never smoked	45.3		41.7		42.8		43.0		44.1		
Former smoker	42.5		48.5		48.5		49.7		49.5		
Current smoker	12.2		9.8		8.7		7.3		6.3		
Moderate and vigorous physical activity, MET-minutes/week		4,852.7 (4,137.7)		4,511.4 (4,024.1)		4,472.8 (3,871.9)		4,470.9 (3,838.5)		4,561.4 (3,853.7)	−255.9 (203.1)
Total daily calories, kcal		1,549.4 (848.8)		1,549.2 (848.6)		1,532.7 (810.5)		1,584.2 (807.7)		1,678.1 (776.7)	149.9 (36.2)[b]
Length of residence in neighborhood, years		19.7 (14.0)		19.8 (14.1)		20.2 (14.1)		19.8 (13.5)		19.8 (13.7)	
Neighborhood socioeconomic-status factor score		−1.8 (1.5)		−1.8 (1.5)		−1.9 (1.5)		−2.1 (1.4)		−1.7 (1.4)	0.05 (0.03)
Moved before visit, %			5.6		9.4		12.7		17.4		
Neighborhood exposures											
Individual-level safety[c]		3.6 (0.9)		3.6 (0.9)		3.6 (0.9)		3.6 (0.9)		3.6 (0.9)	−0.02 (0.04)
Neighborhood-level safety[c]		3.5 (0.4)		3.5 (0.4)		3.5 (0.4)		3.5 (0.5)		3.4 (0.5)	−0.12 (0.01)[b]
Total reported crime per 1,000 persons within 1 mile		94.7 (38.0)		90.3 (34.4)		90.7 (33.8)		91.8 (43.2)		69.6 (39.9)	−21.6 (1.4)[b]
Outcomes											
Body mass index[d]		27.1 (5.3)		27.1 (5.3)		26.9 (5.3)		26.8 (5.3)		26.7 (5.4)	−0.10 (0.13)
Waist circumference, cm		95.0 (14.3)		95.9 (14.6)		95.7 (14.7)		95.2 (14.5)		95.3 (14.9)	1.57 (0.40)[b]

Abbreviations: GED, General Educational Development; MET, metabolic equivalent of task; SD, standard deviation; SE, standard error.

[a] Estimated from linear regression model with random effects for intercept and time slope.

[b] $P < 0.05$.

[c] Higher value indicates more safety.

[d] Body mass index was calculated as weight (kg)/height $(m)^2$.

At baseline, persons reporting higher levels of individual-level safety had greater BMI after adjustment for age, sex, education, race/ethnicity, total calorie intake, neighborhood residence duration, physical activity, income, smoking status, move status, and neighborhood socioeconomic status (mean difference per standard-deviation higher safety = 0.57 (SE, 0.20); $P < 0.05$) (Table 2). There was no significant relationship between cumulative exposure to individual-level safety and BMI trend. The pattern was similar for men and women (interaction $P = 0.39$). Persons who reported higher levels of individual-level safety at baseline also had higher waist circumference (mean difference per standard-deviation higher safety = 1.46 (SE, 0.54) cm). On average, waist circumference increased by 1.34 (SE, 0.41) cm per 10 years ($P < 0.05$ for both). There was also no significant relationship between cumulative exposure to individual-level safety and trends in waist circumference over time; a similar pattern was observed among men and women (P for interaction = 0.99).

Higher neighborhood-level safety was associated with lower BMI and waist circumference at baseline after adjustment, but associations were not statistically significant (Table 2). Cumulative exposure to neighborhood-level safety was not associated with changes over time in BMI or waist circumference. Crime at baseline and cumulative exposure were not associated with BMI or waist circumference.

Associations of higher neighborhood-level safety with lower BMI and waist circumference at baseline persisted after adjustment for individual-level safety (mean difference = 0.70 (SE, 0.25) for BMI and 1.71 (SE, 0.69) cm for waist circumference). Adjustment for individual-level safety did not significantly modify any results regarding associations of neighborhood-level safety or crime with BMI or waist circumference changes over time (Web Table 1, available at https://academic.oup.com/aje).

Table 3 shows results of fixed-effects models. A 1-standard-deviation increase in individual-level safety was associated with a 0.11 (SE, 0.06) BMI decrease ($P < 0.10$) overall. The association was stronger in women than men (in women, −0.21 (SE, 0.10); in men, 0.00 (SE, 0.07); P for interaction = 0.11). An association in a similar direction was observed for waist circumference in women but was not statistically significant (−0.51 (SE, 0.33) cm).

Sex differences were observed between neighborhood-level safety changes and BMI and waist circumference (for BMI, P for interaction = 0.02; for waist circumference, P for interaction = 0.002). Increasing neighborhood-level safety was

Table 2. Mean Difference[a] in Body Mass Index and Waist Circumference at Baseline and Mean Differences in 10-Year Change Over Time Associated with Higher Exposure to Individual-Level and Neighborhood-Level Safety and Police-Recorded Crime, Multi-Ethnic Study of Atherosclerosis, Chicago, Illinois, 2000–2012

Safety and Crime Exposure	Mean Difference in BMI[b] (SE)			Mean Difference in Waist Circumference, cm (SE)		
	Overall	Men	Women	Overall	Men	Women
Individual-level safety (per SD)[c]						
Mean difference at baseline	0.57 (0.20)[d]	0.72 (0.25)[d]	0.45 (0.29)	1.46 (0.54)[d]	1.50 (0.70)[d]	1.59 (0.80)[d]
Mean overall 10-year change at mean of safety	−0.21 (0.13)	−0.20 (0.17)	−0.20 (0.20)	1.34 (0.41)[d]	1.26 (0.50)[d]	1.47 (0.63)[d]
Deviation[e] from mean overall 10-year change associated with 1-SD higher cumulative safety	0.18 (0.14)	0.02 (0.18)	0.28 (0.20)	−0.01 (0.43)	−0.29 (0.55)	0.09 (0.63)
Neighborhood-level safety (per SD)[c]						
Mean difference at baseline	−0.21 (0.22)	0.02 (0.27)	−0.34 (0.34)	−0.47 (0.61)	0.09 (0.74)	−0.63 (0.93)
Mean overall 10-year change at mean of safety	−0.21 (0.13)	−0.20 (0.17)	−0.22 (0.20)	1.34 (0.42)[d]	1.18 (0.51)[d]	1.48 (0.63)[d]
Deviation[e] from mean overall 10-year change associated with 1-SD higher cumulative safety	−0.02 (0.14)	−0.10 (0.17)	0.02 (0.22)	−0.12 (0.45)	−0.44 (0.53)	0.05 (0.69)
Total police-reported crime within 1 mile[f] (per 10 crimes per 1,000 persons)						
Mean difference at baseline	0.07 (0.07)	0.08 (0.08)	0.04 (0.10)	0.08 (0.18)	0.10 (0.21)	−0.03 (0.29)
Mean overall 10-year change at mean of crime	−0.24 (0.14)	−0.16 (0.18)	−0.31 (0.21)	1.46 (0.44)[d]	1.52 (0.53)[d]	1.47 (0.66)[d]
Deviation[e] from mean overall 10-year change associated with a higher cumulative crime exposure	−0.04 (0.05)	0.03 (0.05)	−0.10 (0.07)	0.11 (0.15)	0.26 (0.16)	−0.01 (0.24)

Abbreviations: BMI, body mass index; SD, standard deviation; SE, standard error.

[a] Estimated from a 2-level linear regression model with random effect for individual intercept and time slope. Adjusted for time-invariant variables of age at baseline, sex, education, race/ethnicity, number of years in neighborhood; interactions with time for age at baseline, sex, race/ethnicity, and number of years in neighborhood; and time-varying variables of moderate to vigorous physical activity in quartiles, household income, smoking status, total calorie intake, moved before visit, and neighborhood level socioeconomic-status factor score.

[b] BMI was calculated as weight (kg)/height (m)^2.

[c] For a 1-standard-deviation unit change in safety score. Higher value indicates more safety.

[d] $P < 0.05$.

[e] Estimated from interaction of cumulative average exposure with time in model.

[f] For an increase of 10 crimes per 1,000 persons.

Table 3. Mean Within-Person Changes[a] in Body Mass Index and Waist Circumference Associated With Within-Person Increases in Individual-Level and Neighborhood-Level Safety and Police-Recorded Crime, Multi-Ethnic Study of Atherosclerosis, Chicago, Illinois, 2000–2012

Neighborhood Exposures	Mean Difference in BMI[b] (SE)			Mean Difference in Waist Circumference, cm (SE)		
	Overall	Men	Women	Overall	Men	Women
Individual-level safety[c]	−0.11 (0.06)[d]	0.00 (0.07)	−0.21 (0.10)[e]	−0.24 (0.20)	0.08 (0.23)	−0.51 (0.33)
Neighborhood-level safety[c]	−0.16 (0.09)[d]	−0.37 (0.12)[e]	0.04 (0.14)	−0.03 (0.31)	−0.98 (0.39)[e]	0.94 (0.48)[d]
Total reported crime per 1,000 persons within 1 mile[f]	0.02 (0.02)	0.03 (0.03)	0.01 (0.03)	0.11 (0.07)	0.12 (0.08)	0.10 (0.11)

Abbreviations: BMI, body mass index; SE, standard error.

[a] Estimated from econometric fixed-effects models. Adjusted for time-varying variables of moderate to vigorous physical activity in quartiles, household income, smoking status, total calorie intake, moved before visit, and neighborhood-level socioeconomic-status factor score and for time-invariant covariates with time interactions for age at baseline, sex, race/ethnicity, and number of years in neighborhood.

[b] BMI was calculated as weight (kg)/height (m)^2.

[c] For a 1-standard-deviation unit change in safety score. Higher value indicates more safety.

[d] $P < 0.10$.

[e] $P < 0.05$.

[f] For an increase of 10 crimes per 1,000 persons.

associated with BMI and waist circumference decreases among men ($P < 0.05$); among women, neighborhood-level safety was not associated with BMI and had a marginal positive association for waist circumference ($P < 0.10$). Increasing police-recorded total crime was not significantly associated with BMI or waist circumference for the overall population or in sex-stratified analyses. When accounting for individual-level safety, increasing neighborhood-level safety remained associated with a decrease in BMI and waist circumference for men and an increase in waist circumference among women. Results for crime were unchanged after adjustment for individual-level safety (Web Table 2). There were no significant changes in results from all linear mixed and fixed-effects models when smoking, physical activity, and calorie intake were removed in sensitivity analyses (data not shown).

DISCUSSION

In a multiethnic, population-based cohort of adults, we observed that greater neighborhood-level safety was cross-sectionally associated with smaller BMI and waist circumference after accounting for individual-level safety. In contrast, higher individual-level safety was not associated with adiposity (in fact, the opposite of expected results was observed). Cumulative exposures to safety or crime were not associated with adiposity changes over time. However, in fixed-effects models tightly controlling for time-invariant, person-specific covariates, increases in perceived safety over time, at both the individual and neighborhood level, were associated with BMI decreases for the overall population. Specifically, increasing individual-level safety was associated with decreasing BMI for women, while increasing neighborhood-level safety was associated with decreasing BMI for men. Increases in total crime were not associated with adiposity. These results regarding adiposity changes related to changes in safety were consistent with the study hypotheses.

Changes in anthropometric measurements of a similar magnitude to those seen in our study have been associated with worsening population-level cardiometabolic health (41). Therefore, BMI and waist circumference changes associated with safety are of public health significance. These longitudinal analyses support safety as a potential determinant of body weight and subsequent cardiovascular disease risk in multiethnic populations.

Our study findings add to the literature in several important ways. First, the study expands available data on the relationship between safety and adiposity in diverse populations. While several cross-sectional studies have shown greater individual-level safety to be associated with lower prevalent obesity or decreased BMI (16, 17), paradoxical findings have been observed in the association between individual-level safety and BMI, as in our study (42). However, to our knowledge, no prior study has accounted for both individual-level and neighborhood-level safety perceptions when examining the relationship between individual-level safety and BMI. Neighborhood-level safety constructs can be created with high within-neighborhood and between-neighborhood reliability and likely serve as a “true” neighborhood measure when averaged over multiple respondents (27). Our study showed that greater neighborhood-level safety was associated with lower baseline BMI and waist circumference when adjusting for individual-level safety. These findings provide further evidence that neighborhood environment may relate to adiposity through physiologic stress pathways given prior data, including from the MESA cohort, showing that neighborhood-level safety is associated with cortisol as a stress-related biomarker (43, 44). However, one would expect that individual-level safety would attenuate the relationship between neighborhood-level safety and BMI or waist circumference if psychological stress was a primary mediator in the association between neighborhood environment and adiposity. We hypothesize that we do not observe an attenuation of the relationship by individual-level safety because this relationship between neighborhood-level safety and body size measurement may be confounded by more objective, built-environment factors, such as urban design or transportation infrastructure (45). In these analyses, we are unable to adjust for these built-environment factors in our models, but they may be accounted for in alternative study designs (46).

Our study also adds to limited data on the relationship between neighborhood crime and adiposity. In contrast to our expected findings, living in areas of greater total crime was not associated with higher BMI or waist circumference. Other cross-sectional studies have shown an association between crime and BMI; however, these studies have primarily been conducted in populations outside the United States (3, 5–7). One of the only studies of a US population demonstrated that low-income, uninsured women participating in a cancer screening program had greater baseline BMI and cardiovascular risk as crime increased in their neighborhood zip code (5). Differences in the findings by Mobley et al. (5) from our study findings may relate to location differences, given that our study occurred in Chicago while the other study occurred across 5 states, including both urban and rural areas. Moreover, our findings may differ due to dissimilarities in analyzed crime measurements; we evaluated all police-reported crimes in our models, while Mobley et al. defined crime only by the number of robbery arrests/100,000 county residents.

To our knowledge, this is the first study to examine safety and crime changes over time relative to adiposity changes. Prior work in adolescent populations examined the relationship between individual-level safety and BMI change over time; however, this study did not distinguish between individual-level and neighborhood-level safety or account for change in safety over time (22). In that study of adolescents, greater perceived safety was associated with decreasing BMI over time among Latino boys, but there was no significant association among girls. We have demonstrated that increasing individual-level safety is associated with decreasing BMI and waist circumference for women while increasing neighborhood-level safety is associated with decreasing BMI and waist circumference for men. The association between individual-level safety and obesity appears mediated by psychological distress (47), and the physiologic response to this type of psychological stress when individual-level safety worsens may differ between sexes (48). In particular, sex-specific modulation of the hypothalamic-pituitary-adrenal axis in response to psychological stress may support our study findings. Better understanding of potentially differential effects of neighborhood-level and individual-level safety on adiposity among men and women should be considered a future research priority. Moreover, increasing total crime levels over time did not appear to influence BMI or waist circumference change as strongly as changes in individual-level safety. These findings suggest that the trajectory of perceptions about safety may be more influential on adiposity change over time, as opposed to actual neighborhood crime. The differences in the effects of changes in individual-level safety and total crime on adiposity change are hypothesis-generating, and discovering potential mechanisms to explain these differences requires examination in other longitudinal studies.

The strengths of this study include the multiethnic, population-based cohort from a large urban area; availability of longitudinal data for both exposure and outcome variables, which allowed for analyzing change in safety and crime in relation to adiposity change; and availability of measured height, weight, and perceived safety using validated protocols. However, our analyses were conducted using MESA participants at only the Chicago study site, limiting statistical power and the generalizability of findings. We were limited in our ability to study effects of variability in crime throughout the city of Chicago, although variability in crime trends over time where study participants were located should be accounted for by the time effect in the mixed models and fixed-effects models. Another limitation is that the method used in compiling crime data for our study differs from that used in prior studies (3–7), making comparisons between our study and prior studies more difficult. In addition, the crime data are dependent on crimes reported to the police and do not include unreported crime that occurred in the city of Chicago during the study period. Finally, we are unable to account for confounding by other neighborhood factors, including built environment; however, our estimates are likely conservative, given that this confounding can lead to regression towards the null.

In conclusion, both individual- and neighborhood-level safety are associated with increasing adiposity over time. Our findings further elucidate the influence of neighborhood environment on cardiometabolic health. Furthermore, these results support public health policies and interventions addressing adverse neighborhood conditions that decrease safety for at-risk communities.

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Author affiliations: Cardiovascular and Pulmonary Branch, Division of Intramural Research, National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, Maryland (Tiffany M. Powell-Wiley); Department of Epidemiology and Biostatistics, Dornsife School of Public Health, Drexel University, Philadelphia, Pennsylvania (Kari Moore, Ana V. Diez Roux); Department of Preventive Medicine, Feinberg School of Medicine, Northwestern University, Chicago, Illinois (Norrina Allen); Department of Sociology, Loyola University, Chicago, Illinois (Richard Block); Department of Epidemiology, Gillings School of Global Public Health, University of North Carolina, Chapel Hill, North Carolina (Kelly R. Evenson); and Division of Epidemiology, School of Public Health, University of California, Berkeley, Berkeley, California (Mahasin Mujahid).

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