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Perception of Neighborhood Crime and Drugs Increases Cardiometabolic Risk in Chilean Adolescents

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A B S T R A C T

Purpose: Studies report an association between neighborhood risk and both obesity and cardiometabolic risk factors (CMR) among adolescents. Here we describe the effect of perceived neighborhood risk on adiposity and CMR among Chilean adolescents.
Methods: Participants were 523 low- to middle-income Chilean adolescents. We assessed neighborhood risk in early adolescence, adiposity in childhood and in early and later adolescence, and blood pressure and fasting glucose in later adolescence. Neighborhood risk profiles were estimated using latent profile analysis (LPA) and based on reported perceptions of crime and drug sales/use. Using linear and logistic regression, we examined the effect of neighborhood risk on adiposity and CMR.
Results: Mean age in early and later adolescence was 14 and 17 years, respectively. Participants were 52% male, with a mean BMI *z*-score of .67, and 8% met criteria for metabolic syndrome. LPA identified two neighborhood profiles: 61% *low risk* and 39% *high risk*. In later adolescence, being in the high risk profile predicted a higher BMI *z*-score, waist-to-height ratio, and fat mass index ($p < .05$). Adolescents in the high risk profile had three times greater odds of meeting criteria for metabolic syndrome (OR = 3.1, 95% CI: 1.5, 5.8) compared with those in the low risk profile.
Conclusions: Our findings suggest that there are physiological responses to living in a neighborhood perceived as “risky,” which may contribute to obesity and CMR even in adolescence. For Chilean neighborhoods with high crime and drugs, targeted public health interventions and policies for youth could be beneficial.

IMPLICATIONS AND CONTRIBUTION

- Perceived neighborhood disadvantage, independent of socioeconomic status (SES), predicted higher body mass index (BMI), central adiposity, and metabolic syndrome.
- The relationship between disadvantage type and health may change throughout the life course.
- Perceptions of social environment can have deleterious health effects.

It is well-established that socioeconomic status (SES) relates to health. Yet it remains unclear *how* neighborhood disadvantage damages health while accounting for personal SES and whether the effect of neighborhood disadvantage on health is contextual (neighborhood or collective SES) or compositional (personal or household SES) [1]. Studies in economically developed countries

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have demonstrated an effect of neighborhood contextual factors on adult health independent of individual SES [2,3]. In developing countries, this relationship remains understudied but nevertheless important.

In the United States, United Kingdom, and Canada, studies have shown a relationship between the environment and both obesity and cardiometabolic risk factors (CMR), including metabolic syndrome (MetS), dyslipidemia, and hypertension [4–6]. Many studies have focused on the built environment and residential factors, while few have accounted for neighborhood context and social interactions such as perceptions about crime, safety, and risk behaviors. Neighborhoods with high levels of disorder, such as crime, danger, drug use, and public drinking, have been associated with poor health in residents even after controlling for individual SES [4]. Thus, it is these neighborhood perceptions that may directly or indirectly influence health. Studies show that individuals who feel less threatened by neighborhood crime are less likely to be hypertensive [7] and those who feel threatened are at increased risk for high BMI and heart disease [8]. To understand relationships between neighborhood factors and health, it is important to incorporate neighborhood perceptions as a measure of risk, which as a collective social factor could impair health. Chile is a middle-income country with one of the most uneven distributions of wealth in the world [9]. Similar to large metropolitan areas, Santiago, Chile's capital, has a higher crime rate than that of Chile overall: 29% of households reported having a member be a victim of a crime in Santiago, compared with 26% overall for 2012 [10]. From a list of national problems, crime combined with drug trafficking was the problem most frequently rated as "important" by Santiago residents (24.3% of residents), just ahead of poverty (23.5%) [10]. Income inequality has been examined in Chile, with research providing some evidence that community differences may be related to self-reported poor health [9]. In addition, obesity has reached high proportions comparable to those of the United States, putting Chileans at risk for developing CMR [11].

Most of the literature pertaining to neighborhood context and cardiovascular health is limited for several reasons. First, most studies have focused on self-reported weight and health outcomes. Only a few studies considered CMR. For example, in a recent review [2] of 75 studies in developed countries, 63 examined obesity (48 based on self-report), 12 considered hypertension (six based on self-report), four considered diabetes (three based on self-report), four considered dyslipidemia (one based on self-report), and three considered MetS. Second, most studies have been conducted in adult populations. In the same review by Leal and Chaix, only a third of the 75 studies were conducted with children and adolescents, *none* of which included direct measures of weight. All 75 studies focused on neighborhood context and weight status, with half finding that neighborhood disadvantage related to a higher BMI. To date, there are no longitudinal studies examining the relationship between neighborhood context, CMR, and objectively measured weight status in adolescent populations. If neighborhood disadvantage can accelerate the progression of poor health or disease-related health outcomes, it is important to examine the longitudinal nature of this relationship to prevent the acceleration of these negative health outcomes in adulthood.

The purpose of this study was to examine the relationship between perceived neighborhood crime and drug use and measured BMI, waist circumference, blood pressure, and MetS while accounting for overall household SES in a longitudinal cohort study of adolescents in Santiago, Chile. We used latent profile analysis to group adolescents of low- to middle-income backgrounds by neighborhood characteristics—*high risk* versus *low risk*. We hypothesized that obesity and CMR would be worse in adolescents of a high risk neighborhood profile.

Methods

Study cohort and setting

The current study sample included 535 adolescent participants of low- to middle-income backgrounds in Santiago, Chile. Adolescents and their mothers (or caregivers) were participants in an ongoing longitudinal cohort study, which began as an iron anemia deficiency (IDA) preventive trial between 1991 and 1996 [12]. Healthy infants were recruited from four contiguous low-to-middle income, working-class, communities located in the southern part of Santiago ($n = 1{,}657$). These neighborhoods were selected based on their close proximity to the research site, the Institute for Nutrition and Food Technology (INTA), University of Chile. Details about the enrollment and trial have been previously described [12]. Between 2005 and 2012, the cohort participated in a follow-up of the IDA study at 10 years and 16 years and in two other studies: one related to substance use and neighborhood characteristics in *early adolescence* (between the ages of 12 and 15 years) and the other related to cardiovascular risk in *late adolescence* (between the ages of 16 and 18 years). In late adolescence, we invited a randomly selected subset of 888 adolescents to participate, of whom 679 participants were assessed (76%).

Study design

Our study sample included 535 cohort participants who were assessed at three time points, occurring between 2005 and 2012. For this study, we used data collected at each of these three time points. At 10 years and in early adolescence, assessments were completed by a nurse and research psychologists and in later adolescence by physicians. This study was approved by the Institutional Review Boards at INTA, the University of Michigan, and the University of California, San Diego.

Exposure: Neighborhood risk

Adolescents' subjective perception of their neighborhood was assessed using three questions on neighborhood crime and drug use from the National Survey of American Life: Adolescent Questionnaire [13]. The questions were on a 5-point scale. We asked: "How often are there problems with muggings, burglaries, assaults or anything else like that in your neighborhood?" with response options ranging from "very often" to "never"; "How much of a problem is the selling and use of drugs in your neighborhood?" with response categories "very serious" to "never"; "During the past 12 months, how often have you seen people selling illegal drugs in your neighborhood?" with response categories "almost every day" to "never." We coded the questions to reflect that higher scores represented more neighborhood risk. Questions were pilot tested with participants prior to commencing the study for comprehension, face validity, and language equivalence. Youth reported understanding the questions and response categories.

Outcomes: Cardiometabolic risk factors

We examined five CMR and biomarkers: body mass index *z*-score (BMI), waist-to-height ratio (WHtR), fat mass index (FMI), MetS, and blood pressure (BP) ≥90th percentile. Anthropometry and blood pressure were measured in later adolescence (between 16 and 18 years) by two trained physicians. Weight and height were assessed in duplicate with a Precision Hispana scale and a stadiometer accurate to .1 kg and .1 cm, respectively. Participants were measured without shoes, wearing underwear, in the Frankfurt position. Blood pressure was also measured twice. If first and second measurements did not match for height, weight, and BP, the measurements were repeated. BMI *z*-scores were calculated using World Health Organization (WHO) growth standards, which adjust for age and sex. WHtR was calculated as waist (cm) divided by height (cm) and used as a measure of central adiposity. WHtR is an effective way of measuring abdominal adiposity in youth [14]. BP ≥90th percentile was defined as a systolic or diastolic BP ≥90th percentile for age, sex, and height [15]. Total fat mass was assessed using Lunar Prodigy Dual Energy X-Ray Absorptiometry scan (DXA; GE Healthcare, Madison, WI). We used the Cook criteria for MetS [16], having ≥3 of the following 5 factors: elevated blood pressure, a low high-density lipoprotein cholesterol level, a high triglyceride level, a high fasting glucose level, and abdominal obesity, which are adjusted for age and sex [17]. All participants were measured according to standard protocols on the same machine calibrated every other day. Fat mass index was calculated (fat mass [kg]/height^2 [m^2]).

Covariates

We considered the following covariates: sex, age, BMI at age 10 years and in early adolescence, and maternal BMI (measured when participants were 10 years old). The parent completed a modified Graffar index, which assessed SES [18]. We used the 13 items to obtain a composite score using a linear combination of the mother's completed years of education, the father's completed years of education, maximum level of combined occupational prestige of the mother and father, and family income. SES was standardized so that it had a mean of zero and a standard deviation of 1, with higher values representing higher SES. The created variable was labeled overall (household) SES.

Statistical analyses

We used PASW/SPSS (Version 18; Chicago, IL) to determine descriptive statistics such as frequencies, means, and standard deviations.

Latent profile analysis, an exploratory technique, was used to create neighborhood risk profiles using the items described above. The first step involved fitting a one-profile model to the data to establish a baseline. We tested latent profile solutions of one to three profiles. Models were compared in order to examine the best fit to the data, using the following fit indices: the Akaike Information Criterion (AIC) [19], the Bayesian Information Criterion (BIC) [20], the Adjusted BIC (ABIC) [21], and a bootstrapped Lo–Mendell–Rubin Test (LMRT) [22]. Sample sizes, and interpretability of the profiles determined the number of latent profiles. These indices allow for the comparison of non-nested models and for the selection of the true model when that model is a candidate, and minimize useful risk functions when the true model is not a candidate. Smaller AIC, BIC, and ABIC values, and a significant LMRT test (i.e., $p < .05$) indicated the "higher profile" solution fit the data better (e.g., two-profile better than one-profile). Lastly, an entropy value approaching 1.0 was used to indicate a clear distinction between profiles [23]. Because there is no criterion for "good" fit, these values were useful when comparing two or more models.

The estimated profiles were examined for group differences using independent *t*-tests and *Chi*-square tests. We performed a cross-sectional analysis to examine the relationship between neighborhood profile and BMI in early adolescence, controlling for previous BMI at age 10 years. Longitudinal analyses were performed to examine the effect of neighborhood risk profile on health outcomes in later adolescence. Although we assessed the impact of neighborhood risk on meeting MetS criteria, we also examined neighborhood risk independently with WHtR and BP to understand the impact of neighborhood risk on each outcome. Multivariate linear regression models were estimated for each continuous health outcome: BMI *z*-score, WHtR, and FMI. Logistic regression was employed to explore odds of MetS and BP ≥90th percentile. All models controlled for household SES, sex, age, BMI at 10 and 14 years old, and maternal BMI. BMI at age 10 years was controlled for in early adolescence, with BMI at 14 years of age being controlled for in later adolescence. Overall SES was included in all models; age in models of waist:height; and sex in models of waist:height and BP. Maternal BMI was controlled for in all weight-related models. All statistics were performed using a *p* value significant at $p < .05$. All LPA and multivariate analyses were performed using the MPlus 6 software (Muthen & Muthen). For multivariate analyses we report standardized betas.

Results

A summary of participant characteristics is provided in Table 1. Fifty-four percent of participants were male. Participants were, on average, 14 years old in early adolescence and 17 years old in later adolescence. At both time points, the mean BMI *z*-score was .7, with over a third being classified as overweight/

Table 1
Characteristics of low- to middle-income adolescents in Santiago, Chile, overall and by neighborhood profile[a]

	Overall n = 535	Low risk n = 319	High risk n = 216
Cardiometabolic risk factors			
Female, (%)	48.2	53.3	40.7
Overweight/obese at 14 y, (%)*	38.0	36.5	40.4
Overweight/obese at 17 y, (%)	37.8	35.1	41.7
BMI *z*-score at 10 y	.8 (1.0)	.8 (.9)	.8 (1.0)
BMI *z*-score at 14 y	.7 (1.0)	.6 (.9)	.7 (.9)
BMI *z*-score at 17 y	.7 (1.2)	.5 (1.1)	.8 (1.2)
Meets MetS criteria, (%)*	8.4	5.2	13.2
BP ≥90th percentile, (%)	12.1	10.3	14.8
DBP ≥90th percentile, (%)*	7.1	.04	11.6
SBP ≥90th percentile, (%)	8.4	7.5	9.7
Waist:height (cm)*	.4 (.1)	.4 (.1)	.5 (.1)
Fat mass index	7.2 (3.9)	7.1 (3.8)	7.5 (4.2)
Socioeconomic status			
Overall SES *z*-score	−.03 (1.0)	.02 (1.0)	−.11 (.8)

BMI = body mass index; BP = blood pressure; DBP = diastolic blood pressure; MetS = metabolic syndrome; SBP = systolic blood pressure; SES = socioeconomic status.
[a] Values are mean (SD) or %.
* $p < .05$, *t*-test or *Chi*-square test of differences between neighborhood profile.

obese. In later adolescence, 8% met criteria for MetS and 12% had a BP ≥90th percentile.

The AIC, BIC, ABIC, entropy (.93), and the bootstrapped LMR test all supported a two-profile over a one-profile solution of neighborhood risk ($p < .0001$ for all). The model fit estimates also indicated that three- and four-profile solutions were possible. However, we chose a two-profile solution because this produced reasonable model-based means with standard errors, sample sizes per profile and interpretable neighborhood profiles. Table 2 shows model-based means and standard errors for each latent neighborhood profile. Profile 1 was labeled as "low risk" and included 60% of the sample in early adolescence. This profile was characterized by lower report of crime and illegal drug behavior in the neighborhood. Profile 2 (40%) labeled "high risk" was characterized by higher report of these neighborhood behaviors. In the later adolescent period, there were significant differences in CMR by neighborhood profiles, as shown in Table 1. Specifically, in the high risk profile, a higher percentage of adolescents met the criteria for MetS. Those whose neighborhood profile was high risk also had a slightly higher WHtR. In addition, those with a high risk neighborhood profile had a higher frequency of diastolic blood pressure (DBP) ≥ 90th percentile compared with the low risk group.

The cross-sectional analysis showed no significant association between neighborhood profile and BMI in the early adolescent period. BMI *z*-score at 10 years old and maternal BMI were significant predictors of BMI *z*-score in early adolescence ($\beta = .83$, $\beta = .02$; respectively), with overall SES ($\beta = -.06$) being a protective factor. Table 3 shows results for multiple regressions for both continuous and categorical health outcomes, with neighborhood profile patterns (measured in early adolescence) being the independent variable of interest. Being in the high risk neighborhood profile during early adolescence predicted a higher BMI *z*-score ($\beta = .04$) in later adolescence, after adjusting for overall SES, BMI in early adolescence, and maternal BMI. BMI in early adolescence was associated with a BMI in later adolescence ($\beta = .88$). This model accounted for 79% of the variance in BMI *z*-score. Also, being in the high risk neighborhood profile predicted a higher WHtR in later adolescence ($\beta = .07$), after adjusting for the same covariates plus sex and age. Females had a significantly higher WHtR compared with males ($\beta = .11$). This model accounted for 60% of the variance in WHtR. Living in a high risk neighborhood also predicted higher FMI, adjusting for the same covariates. BMI at age 14 years, age, female sex, and maternal BMI were all significantly and positively related to FMI (see Table 3). BMI in early adolescence was associated with BMI in later adolescence ($\beta = .79$) and accounted for half of the explained variance in the final model for FMI.

In the later adolescent period, the odds of meeting criteria for MetS were three times greater for adolescents in the high risk neighborhood profile (OR = 2.9, 95% CI: 1.5, 5.8) than for adolescents in the low risk neighborhood profile, after controlling for overall SES. Neighborhood profile accounted for 5% of the variance in MetS. Neighborhood profile patterns did not predict BP ≥90th percentile after controlling for sex, BMI at age 14 years, and overall SES. During later adolescence, BMI was associated with a twofold increase in the odds of having a BP ≥90th percentile (OR = 2.2, 95% CI: 1.7, 2.8). BMI accounted for 16% of the variance in the model for BP. Separate models were examined for systolic and diastolic BP ≥90th percentile, but neighborhood profile was not significantly related to high BP in either model (results not shown).

Table 2
Perception of neighborhood crime and drug activity[a], overall and by neighborhood profile[b]

	Overall	Low risk	High risk
Crime	2.9 (.05)	2.5 (.06)	3.4 (.09)
Selling and use of drugs	3.7 (.06)	3.2 (.08)	4.5 (.06)
Witness illegal drug sales	2.4 (.07)	1.3 (.04)	4.3 (.07)

[a] Response options ranged from 1 to 5, higher values indicate greater neighborhood risk; values are mean (SE).
[b] Neighborhood profile: estimated using latent profile analysis.

Table 3
Multivariate regressions of the effect of neighborhood profile on cardiometabolic risk

	Linear regressions[a]				Logistic regressions[b]	
	BMI *z* 14 y	BMI *z* 17 y	WHtR 17 y	FMI 17 y	MetS 17 y	BP ≥90th percentile 17 y
High risk profile[c]	.02	.04*	.07*	.06*	2.9 (1.5–5.8)*	1.3 (.7–2.4)
BMI 10 y	.83*					
BMI 14 y		.88*	.71*	.67*		2.3 (1.6–3.3)*
Age			.13*	.07*		
Female			.22*	.42*		
Maternal BMI	.06*	.03	.04	.07*		
Overall SES	−.06*	.01	−.03	−.01	.8 (.6–1.2)	.9 (.6–1.2)
R-square	.71	.79	.60	.69	.05	.16

BMI = body mass index; SES = socioeconomic status.
[a] Values are standardized betas.
[b] Values are OR (95% CI).
[c] Reference = low risk profile.
* Significant at $p < .05$.

Discussion

The present study identified two types of neighborhood patterns in low- to middle-income working class neighborhoods of Santiago, Chile based on perception of crime and drug dealing. Consistent with previous work in adult populations, living in a neighborhood profiled as high risk predicted several CMR in adolescents. Specifically, a neighborhood profile characterized as high risk in early adolescence predicted a higher BMI, WHtR, FMI, and meeting criteria for MetS in later adolescence even after controlling for covariates, such as sex, age, prior BMI, and overall SES when appropriate. Although neighborhood profile did not predict BP, the high risk neighborhood profile had a higher frequency of adolescents with a DBP ≥90th percentile compared with those in the low risk neighborhood profile.

Our findings suggest that chronic exposure to the perception of living in a high risk neighborhood impacted the health of Chileans from early to late adolescence. We found no empirical evidence of a cross-sectional relationship between neighborhood risk patterns and BMI during the early adolescent period, after adjusting for confounding factors. In the early adolescent period, childhood BMI (assessed at 10 years) was a significant predictor of BMI, with higher household SES having a small, yet protective relationship for BMI. Neighborhood risk patterns reported in early adolescence consistently predicted health outcomes in later adolescence, specifically a higher BMI, WHtR, FMI, and greater odds of MetS even after controlling for family SES, prior BMI, and other covariates. These findings suggest that in childhood and early adolescence the relationship between being socioeconomically disadvantaged and obesity is compositional (i.e., related to household-level factors). However, as adolescents gain independence and freedom to navigate their neighborhood this relationship may become contextual (i.e., related to neighborhood/environmental-level factors).

Other possibilities of the neighborhood effect could relate to its influence on physical activity. We did not examine physical activity as a risk factor of CMR and obesity, but it is well-established that physical activity declines with age, even within adolescence. The decline in physical activity during adolescence, perhaps due to peer influence, coupled with neighborhood risk may take a toll on adolescent health over time. Studies consistently show that in low-income neighborhoods, with high levels of disorder, children are less physically active [24,25]. In some developing countries and urban areas elsewhere, parents do not allow children to play outside unsupervised due to crime. If children do not learn to be physically active early on, it is unlikely that they will become physically active in adolescence. This may be the case in Santiago where low levels of physical activity are reported among children [26]. In our sample, parents may have been less encouraging of outdoor activities due to high levels of crime and illicit behaviors involving drug use and sales. Furthermore, as adolescents developed their own awareness and perceptions of their neighborhood, their risk perceptions could have acted as a barrier to physical activity, particularly in riskier neighborhoods with limited facilities and resources for physical activity. Additionally, recent statistics estimated that air pollution levels in Santiago were high in comparison with those in North America [27], which may decrease opportunities for physical activity. Lastly, peer influence on diet could have resulted in poor nutrition. Over time these factors could have simultaneous and negative effects on adolescent health.

A potential weakness of the current study is that the sample was constrained to low- to middle-income Chilean adolescents living in an urban setting of Santiago, Chile. Therefore, our findings may not generalize to rural or high-income Chilean populations. Additionally, our measure of "neighborhood risk" may not represent perceived neighborhood risk. Actual crime statistics may have been more reliable. In Chile, however, perception and reported safety are not always in agreement. In the 2011 National Survey of Urban Citizen Safety, 43% of Santiago residents reported perceiving themselves as a victim of a crime in the next year, yet the 2012 survey revealed that 29% reported being a victim of a crime, indicating that Santiago residents perceive themselves to be more vulnerable than the actual documented crime statistics imply [10]. Thus, using perceived neighborhood risk as a predictor is a strength for several reasons. First, perceived neighborhood risk may have captured a better picture of neighborhood crime and drug use as residents are more aware of the daily hassles in their surrounding environment than researchers who may not be privy to such issues during field observations. Additionally, perceived danger has been related to stress reaction and decreased opportunity to being outdoors [28,29]. In this vein, we assessed social interactions as a measure of neighborhood context, which is understudied in the area of neighborhood disadvantage and CMR. This study also contributes to the growing literature on adolescent health in developing countries, specifically in Chile where obesity is a concern. A major strength of this study was the use of objective measures for health outcomes and repeated measures of adiposity. As such, we were able to control for past and current weight status. We also controlled for household SES, which allowed us to examine contextual and compositional relationships between neighborhood socioeconomic characteristics and adolescent health.

A major strength of the study is the longitudinal design, allowing us to establish temporal precedence. Adolescents were asked about their neighborhood two to three years before the health assessments occurred. We found that a high risk neighborhood profile significantly predicted worse health outcomes related to adiposity. Thus, these data provide evidence that the negative perceptions of one's social environment can have serious and deleterious health effects on adolescents. Strategies to decrease crime and drug dealing in neighborhoods could result in improved adolescent health outcomes. Such efforts, however, require resources that are often unavailable. Thus, our findings suggest that clinicians and public health practitioners should consider neighborhood risk as a sign of vulnerability for increased obesity and CMR. As such, practitioners may more effectively address making healthy lifestyle choices to engage in health-protective behaviors.

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