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Neighbourhood poverty, perceived discrimination, and central adiposity: Independent associations in a repeated measures analysis

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SUMMARY

This study examines the independent effects of neighbourhood context (i.e. neighbourhood poverty) and exposure to perceived discrimination in shaping risk of obesity over time. Weighted 3-level hierarchical linear regression models for a continuous outcome were used to assess independent effects of neighbourhood poverty and perceived discrimination on obesity over time in a sample of 157 Non-Hispanic Black, Non-Hispanic White, and Hispanic adults 2002/2003 and 2007/2008. Independent associations were found between neighbourhood poverty and perceived discrimination with central adiposity over time. Residents of neighbourhoods with high concentrations of poverty were more likely to show increases in central adiposity compared to those in neighbourhoods with lower concentrations of poverty. In models adjusted for BMI, neighbourhood poverty at baseline was associated with greater change in central adiposity among participants who lived in neighbourhoods in the second (B=3.79, P=0.025) and third (B=3.73, P=0.024) quartiles, compared with those in the lowest poverty neighbourhoods.

Results from models that included both neighbourhood poverty and perceived discrimination showed that both neighbourhood poverty and discrimination were associated with increased risk of increased central adiposity over time. Residents of neighbourhoods in the second (B=9.58, P<0.001), third (B=8.25, P=0.004), and fourth (B=7.66, P=0.030) quartiles of poverty remained more likely to show greater increases in central adiposity over time, compared with those in the

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lowest poverty quartile, mean discrimination at baseline independently and positively associated with increases in central adiposity over time (B= 2.36, P=0.020). These results suggest that neighbourhood poverty and perceived discrimination are independently associated with heightened risk of increases in central adiposity over time. Efforts to address persistent disparities in the central adiposity in the USA should include strategies to reduce high concentrations of neighbourhood poverty as well as discrimination.

For the past decade, over one-third of adults in the US have been considered obese. Obesity is a precursor for several chronic diseases, including cardiovascular disease (CVD) (1); type II diabetes (2); stroke (3); breast cancer (4), endometrial cancer (5), and ovarian cancer (6). Individuals with central adiposity, a form of obesity where excess fat accumulates in the abdominal area, experience increased risk of CVD and diabetes (7).

Several studies have documented associations between neighbourhood poverty and obesity (8–10). In the United States, race-based residential segregation has contributed to the contemporary patterning of neighbourhoods, with non-Hispanic Blacks (NHBs) and Hispanics being more likely to reside in high-poverty neighbourhoods than non-Hispanic whites (NHWs) (11). The disproportionate representation of NHBs and Hispanics in neighbourhoods with high concentrations of poverty may contribute to racial disparities in obesity (12–14).

There are multiple pathways through which neighbourhood poverty may affect obesity, including associations with characteristics of the physical and social environment. There is substantial evidence linking neighbourhood poverty to limited access to healthy foods (15–17), and to physical environmental characteristics associated with reduced physical activity (18–21), both of which are associated with obesity (22–24). Jackson and Knight (25), theorized that under stressful living conditions, individuals may engage in behaviours associated with poor health, including smoking, alcohol, and overeating. Further, Jackson and colleagues (26), found evidence that engaging in unhealthy behaviours may alleviate symptoms of stress and associated biological cascade which can lead to mental disorders. Conversely, they found evidence to suggest that these unhealthy behaviours, over the life course, contribute to a detrimental effect on physical health. For example, unhealthy behaviours such as overeating of comfort foods (i.e. high-fat, high carbohydrate) while potentially protective of mental health, can lead to increased risk of obesity (26).

Social environments that are conducive to psychosocial stress – that is, environments that are perceived as harmful, threatening, or bothersome (27) - may also be associated with obesity. Physiological responses to stressful environments may cause metabolic changes that, in turn, influence the distribution of fat in the body (28–30). Specifically, these physiologic changes can lead to fat deposits in internal, visceral adipose tissues (29–34).

Several studies have demonstrated associations between perceived discrimination, one indicator of psychosocial stress (35), and adverse physical and mental health outcomes, including hypertension, depression, and cardiovascular disease (36–44). As noted above, one pathway through which these effects may operate is through physiological as well as behavioural responses to stress that contribute to central adiposity. Early studies of perceived

discrimination and central adiposity were primarily cross-sectional, and reported mixed findings (38, 39, 45–47). Longitudinal studies have more consistently reported positive associations between discrimination and central adiposity (40, 48–50). The findings are reviewed below.

Findings from cross-sectional studies of associations between discrimination and obesity vary by race/ethnicity and gender. Hunte and Williams (39), using cross-sectional data from Chicago Community Adult Study, reported positive associations between perceived ethnic discrimination and high-risk waist circumference for ethnic NHWs (i.e., Polish, Irish), but not other whites, NHBs or Hispanics (39). Hickson and colleagues (38) reported a positive association between perceived discrimination and visceral fat among NHB women but not NHB men (38) in a cross-sectional sample in Jackson, Mississippi. Finally, Vines and colleagues (47), using cross-sectional data of African American women who participated in the National Institute of Environmental Health Sciences Uterine Fibroid Study, reported a negative association (47) between perceived racism and central adiposity.

Cozier and colleagues (48) using longitudinal data from the Black Women's Health Study (BWHS) found a positive association between racial discrimination and weight change. However, the BWHS sample was not representative of US Black women, and is not generalizable to Black women with less than a college education (40, 48, 49). Hunte (40) analysed the MIDUS cohort of predominantly White adults and found a positive association between interpersonal discrimination and central adiposity. Cunningham and colleagues (50) using the US CARDIA study reported a positive association between racial discrimination and central adiposity among NHB women, but not NHB men or NHWs (50).

Only one longitudinal study examined how discrimination operates in conjunction with neighbourhood context. Cozier and colleagues' (49) reported a positive association of racial discrimination with incident obesity, irrespective of segregation levels (49). They also report that women who lived in neighbourhoods in the highest quartile of percent African Americans were significantly more likely to become obese over time.

Despite a substantial literature linking neighbourhood poverty with obesity (13, 51, 52), none of the studies described above (38, 39, 45) have examined associations between perceived discrimination and concentration of poverty on obesity over time in the same models. This paper examines two pathways over time that may influence increases in central adiposity: neighbourhood poverty and everyday unfair treatment (a measure of perceived discrimination). The use of multilevel models can help to disentangle the effects of neighbourhood poverty and discrimination, as an individual level indicator of stress on obesity. The longitudinal design can determine the direction of the association – that is, whether individuals who experience higher discrimination are more likely to become obese, or whether individuals who are obese experience higher levels of discrimination. Thus, this study extends previous research by examining the effects of neighbourhood poverty and discrimination on central adiposity in a multi-ethnic sample over time.

METHODS

A prospective 6-year follow up study design drawing upon three data sources was used: The Healthy Environments Partnership (HEP) Wave I (2002/2003) and Wave II (2007/2008), community surveys, and the 2000 Decennial Census. The HEP Wave I Community Survey was conducted in 2002/2003 with a stratified two-stage probability sample of occupied housing units in Detroit. The survey was designed for 1000 completed interviews of NHB, NHW, and Hispanic adults aged ≥25 years. At each household unit, a listing of eligible residents was completed, and one eligible adult was selected randomly for inclusion in the study. The final sample consisted of 919 people: face-to-face interviews were completed with 75% of households in which an eligible respondent was identified (919 of 1,220), and 90% of households in which an eligible respondent was contacted (919 of 1,027) (19). Sample weights were constructed to adjust for differential selection and response rates, allowing us to estimate population effects from the HEP sample.

The 2007/2008 HEP Wave II community survey (n=460) was a follow up survey in which interviews were conducted with current residents of housing units included in the Wave I survey. Of these, 219 were re-interviews of participants included in the 2002/2003 sample and 241 were new residents of the housing unit. The 219 participants were nested within 62 census block groups (19).

Measures

Dependent variable—The dependent variable was a continuous measure of **waist circumference** in centimetres, assessed by interviewers in 2002/2003 and 2007/2008.

Individual level independent variables—The construct of perceived discrimination is operationalized in this paper with the measure of “everyday unfair treatment”, where we do not inadvertently suggest that discrimination is to be interpreted solely as racial discrimination. **Everyday unfair treatment** was a continuous measure of discrimination at baseline, constructed as a mean scale of five items from 1–5 (i.e., how often have any of the following things happened to you? 1. You are treated with less courtesy or respect than other people., 2. You receive poorer service than other people at restaurants or stores, 3. People act as if they think you are not smart., 4. People act as if they are afraid of you., 5. You are threatened or harassed., in the previous 12 months) (range 1=never, 5= always) (Cronbach’s alpha 0.77) (35). The subsequent question, not used for this analyses, asked participants what they thought the unfair treatment was due to, and responses included a wide range of factors, including race, gender, weight, socioeconomic status, language and others.

Individual level control variables—Controls consisted of a dummy variable representing time (0=2002, 1=2008), age (years), gender (1=female, 0=male); two dummy variables representing self-reported race/ethnicity (NHB, Hispanic, NHW=referent); education (<12 years,12 years, ≥12 years=referent); the ratio of income-to-poverty (PIR) (53) was calculated by dividing the household income by the federal poverty threshold for the related family size, a dichotomous version of this variable was used, with PIR>1 indicating household income greater than poverty level and PIR ≤1 (referent) indicating household income at or below the poverty level; marital status (1=married, 0=single,

widowed, or divorced); car ownership (1= owns or leases car, 0= no car); and home ownership (1=owns home, 0= does not own home), and Body Mass Index (BMI) (≥30). Age and BMI varied over time, while the other controls were invariant over time.

Behavioural control variables were included in the final models to assess whether neighbourhood poverty exerted an effect on central adiposity above and beyond the effect of health behaviours. Behavioural control variables included **alcohol use** (54), which was constructed by mean daily frequency intake of alcoholic beverages reported on the modified Block 98 questionnaire: beer, red wine, wine, and liquor. For the four alcoholic beverages, reported intake frequencies, ranging from never to everyday, were converted into the number of drinks per month ranging from 0 to 300. Because the variable was skewed, with 50% indicating zero drinks in the last month, the variable was converted to a binary variable that represents individuals with less than 1 drink per month=0 and individuals with 1 or more drinks per month=1 (55). **Current, never, or former smoker** (56) (e.g., "Do you currently smoke cigarettes") was constructed by using the self-report of whether the individual smoked (1=current, 0=never smoked, or 2=formerly smoked). The **healthy eating index (HEI)** (57) was constructed by taking the sum of mean daily frequency of intake of foods that consist of grains, meat, milk, vegetables, fruit, fat, saturated fat, sodium, and cholesterol reported on the modified block 98 semi-quantitative food frequency questionnaire. For the ten food categories, reported intake frequencies, ranging from never to six or more times per day, were converted to daily frequencies using the following weights: "never or less than once a month" =0, "1–3 times a month" = 0.1, "4–6 times a month"=5/7, "1 time every day" = 1, "2–3 times every day"=3, "4–5 times every day"=5, and "6 or more times every day"=6. The study used a modified version of the HEI, which included a composite measure of 5 food groups and 4 nutrients related to daily servings that is widely used as an overall indicator of dietary quality. The final modified-HEI ranged from 0–90, with a higher number representing healthier consumption of foods. **Physical activity** was captured by asking how many days and the amount of time an individual reported moderate-intensity activities (vacuuming, gardening, or anything else that causes small increases in breathing or heart rate) or vigorous activities (such as fast walking, running, dancing, or participating in strenuous sports that cause large increases in breathing or heart rate) in a usual week for at least 10 minutes at a time (58). Metabolic equivalent of task (MET) minutes of PA per week were calculated for participants for whom data were available. The frequency and duration of physical activity was scaled (divided) by the standard deviation to create a standardized PA score (range- 0–4.2), utilizing guidelines based on the International Physical Activity Questionnaire (58). *Neighbourhood level independent variables*. To assess whether residing in neighbourhood poverty at baseline was associated with changes in waist circumference over time, the time-invariant independent variable **neighbourhood percent poverty** (i.e., percent poverty) was derived from the 2000 census and was categorized into quartiles at the block group-level: Quartile 1, 0–20%, Quartile 2, 20–30%, Quartile 3, 30–40%, and Quartile 4, >40%.

Statistical Analysis—Weighted 3-level hierarchical linear regression models for a continuous outcome were estimated to account for the longitudinal and nested structure of the data. Pregnant or breastfeeding (n=23) individuals, and those missing a measure for

waist circumference (n=60) were removed from the analysis. In addition, since HLM cannot handle unbalanced data for the time varying measures, individual (level-2) and neighbourhood (level-3) levels with missing data were removed from the analysis (n= 5). The final models included the remaining 314 repeated measures (level 1), nested in 157 individuals (level 2), and 56 census block groups (level 3) (i.e. clusters of blocks that generally contain between 600–3000 people in the same census tract). The 241 individuals without repeated measures were excluded from the analyses.

To examine whether neighbourhood percent poverty was significantly associated with waist circumference, multilevel models were analyzed. The neighbourhood percent poverty measure was added to the level-3 intercept. Level 2 adjusted the model for gender, race/ethnicity, education, ratio of income-to-poverty, marital status, car ownership, home ownership, alcohol use, smoking, HEI, and METs. To assess the longitudinal nature of this association, Level 1 was adjusted for time (59). In addition, in final models age was allowed to vary over time within individuals, resulting a better fit of the model, demonstrated by a larger intraclass correlation coefficient (Model 1). Model 2 additionally adjusted for BMI.

$$\begin{aligned}\mathrm{WCIR}_{\mathrm{ijk}} = {} & \gamma_{000} + \gamma_{001} * \mathrm{QUART2}_k + \gamma_{002} * \mathrm{QUART3}_k + \gamma_{003} * \mathrm{QUART4}_k \\ & + \gamma_{010} * \mathrm{PIR}_{\mathrm{jk}} + \gamma_{020} * \mathrm{CAROWNERSHIP}_{\mathrm{jk}} + \gamma_{030} * \mathrm{FEMALE}_{\mathrm{jk}} + \gamma_{040} * \mathrm{HISPANIC}_{\mathrm{jk}} \\ & + \gamma_{050} * \mathrm{WHITE}_{\mathrm{jk}} + \gamma_{060} * \mathrm{OTHER}_{\mathrm{jk}} + \gamma_{070} * \mathrm{MARRIED}_{\mathrm{jk}} + \gamma_{080} * \mathrm{HOMEOWNERSHIP}_{\mathrm{jk}} \\ & + \gamma_{090} * \mathrm{DRINK}_{\mathrm{jk}} + \gamma_{0100} * \mathrm{SMOKE}_{\mathrm{jk}} + \gamma_{0110} * \mathrm{HEI}_{\mathrm{jk}} + \gamma_{0120} * \mathrm{MET}_{\mathrm{jk}} \\ & + \gamma_{0130} * \mathrm{LESS12}_{\mathrm{jk}} + \gamma_{0140} * \mathrm{YEARS12}_{\mathrm{jk}} + \gamma_{100} * \mathrm{AGE}_{\mathrm{ijk}} + \gamma_{200} * \mathrm{TIME1}_{\mathrm{ijk}} \\ & + r_{0\mathrm{jk}} + u_{00k} + e_{\mathrm{ijk}}\end{aligned}$$

Model 1

$$\text{Model 1} + \text{BMI}$$ Model 2

Finally, multilevel models were run to examine the effects of neighbourhood poverty and everyday unfair treatment in the same model (Model 3). Everyday unfair treatment was added to the level-2 intercept controlling for the same controls included in Models 1 and 2. All models were grand mean centered.

$$\text{Model 2} + \text{EvUnTr}$$ Model 3

Additional models were tested to assess sensitivity of results in models with and without behavioural controls. The inclusion of these variables produced a better fit for the model so the final models included behavioural controls. We also tested additional models adjusting for time-varying covariates, such as everyday unfair treatment, METs, smoking, and alcohol use at baseline and follow-up; these covariates were not statistically significant in the models. Moreover, their inclusion did not affect the fit of the models (results not shown).

RESULTS

Complete data were available for 157 participants. Descriptive characteristics of the sample are presented in Table 1. The mean waist circumference was 102.3 cm (S.D. = 2.36). The mean level of everyday unfair treatment was 1.6 (S.D. <0.01). The mean neighbourhood poverty level was 31.3 (S.D. = 10.90).

Model 1 (Table 2) shows results for the first research question, “Is neighbourhood poverty at baseline associated with change in central adiposity over time?”. Participants who lived in neighbourhoods in the second (B=9.58, P<0.001), third (B=8.25, P=0.004), and fourth (B=7.66, P=0.030) quartiles of poverty had greater increases in central adiposity over time, compared with those in the lowest poverty quartile.

In Table 2, Model 2 shows findings for the second research question, “Is neighbourhood poverty at baseline associated with change in central adiposity over time after adjusting for body mass index?”. The results show that neighbourhood poverty at baseline is associated with greater change in central adiposity over time among participants who lived in neighbourhoods in the second (B=3.79, P=0.025) and third (B=3.73, P=0.024) quartiles, compared to those in the lowest poverty quartile. Increases in central adiposity were marginally significantly greater for those in neighbourhoods in the fourth quartile (B=3.15, P=0.074), compared to those in the lowest poverty neighbourhoods.

Model 3 of Table 2 shows findings for the last research question, “Are perceived discrimination and neighbourhood percent poverty associated with changes in waist circumference?” The results show that everyday unfair treatment at baseline and neighbourhood poverty each are associated with changes in waist circumference over time. When discrimination was included in the models, residents of neighbourhoods in the second (B=3.62, P=0.039), third (B=3.640, P=0.044), and fourth (B=3.61, P=0.048) quartiles of neighbourhood poverty remain more likely than those in the lowest poverty neighbourhoods to have greater increases in waist circumference over time. Everyday unfair treatment was positively associated with changes in central adiposity over time (B= 2.36, P=0.020) above and beyond the effects of neighbourhood poverty, in fully controlled models. Patterns are similar for models controlling for BMI at baseline.

DISCUSSION

This analysis yielded three main findings. First, it adds to the body of evidence suggesting associations between neighbourhood poverty and increases in central adiposity over time. In particular, residents of neighbourhoods in which 20% or more of residents have household incomes below the poverty line were more likely to experience greater increases in central adiposity over time. Second, residents of neighbourhoods in which 20% or more of households had incomes below the poverty line were more likely to experience greater increases in central adiposity over time, even after adjusting for BMI at baseline. Finally, neighbourhood poverty and everyday unfair treatment are independently associated with increases in central adiposity. Each of these findings are discussed in greater detail below.

A substantial body of evidence links neighbourhood poverty with reduced access to healthy foods (17), contributing to dietary practices linked to obesity (24), and there is some evidence that neighbourhoods with higher rates of poverty may be more likely to be less conducive to physical activity (18, 19, 60), another important contributor to obesity. However, this study's findings suggest that neighbourhood poverty is associated with increased risk for central adiposity over time, above and beyond individual health-related behaviours (i.e., alcohol use, smoking, HEI, and METs). These results suggest that pathways linking neighbourhood poverty and central adiposity are not limited to effects on behavioural pathways. They are consistent with the hypothesis that effects of neighbourhood poverty on obesity risk may extend beyond these behavioural influences. Several studies have suggested that neighbourhood poverty is associated with exposure to social and economic environments that are conducive to psychosocial stress (9, 55, 61). For example, living in a high poverty neighbourhood is associated with a range of negative factors, from pollution and environmental toxins to violence exposure and over policing (62). Associations between neighbourhood poverty and change in central adiposity over time shown in these models are significant after accounting for behavioural indicators associated with obesity lend credence to pathways that include factors above and beyond those that shape health-related behaviours, such as those associated with psychosocial stress.

Together, findings reported here are consistent with the theory that both social and economic environments shape obesity risk. They join a small but growing body of evidence suggesting positive associations between perceived discrimination and obesity (40, 48, 49),

The findings presented here extend previous research by showing that, when included in models together, neighbourhood poverty and perceived discrimination are each associated with increased central adiposity. These findings suggest that urban populations who experience both higher rates of neighbourhood poverty (i.e., 20% or above) and who experience higher levels of perceived discrimination may be particularly at risk of increases in central adiposity and associated adverse health outcomes over time. Furthermore, these results suggest that these effects travel through distinct pathways, suggesting that efforts to intervene should consider both.

Limitations

This paper has several limitations. First, this study focused on the independent associations between neighbourhood percent poverty and everyday unfair treatment and central adiposity. It is possible that other measures of neighbourhood context, like neighbourhood racial composition, may further help to characterize pathways to increased risk of obesity among urban populations over time. Future studies should consider additional measures that may influence these associations. In addition, we did not directly measure all potential pathways linking neighbourhood poverty to central adiposity. Future studies may consider accounting for food and physical activity environments, as well as contexts contributing to psychosocial stress, in order to disentangle the pathways through which neighbourhood poverty influences central adiposity over time

Conclusions

In conclusion, concentrations of poverty and perceived discrimination at baseline were each positively associated with increased central adiposity over time in this multi-ethnic sample, in models that included both measures. These findings suggest that both social and economic environments influence the patterning of central adiposity and underscore the importance of addressing the factors that contribute to high concentrations of poverty and heightened experiences of discrimination in taking action to address obesity. Efforts to address high concentrations of neighbourhood poverty and discrimination are imperative to reduce persistent disparities in central adiposity. In addition to their many other social and economic benefits, interventions that improve economic environments and reduce high concentrations of poverty in predominantly NHB and Hispanic neighbourhoods, and that address the social forces that contribute to interpersonal discrimination can contribute to decreases in central adiposity in communities who currently experience high risk of obesity and related adverse health outcomes.

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TABLE 1

Weighted Descriptive Characteristics for Individual- and Neighborhood Level Variables: Healthy Environments Partnership Community Survey, Detroit, MI 2002–2003

Individual (Levels 1 and 2) (n =157)	**Mean ± SD**	**%**	**Range**
Age	49.1 ± 0.8		26.0 – 87.0
Female		51	
White		22	
Black		45	
Hispanic		31	
Less than high school		43	
High school		24	
More than high school		33	
Below poverty		36	
Married		32	
Car Ownership		73	
Home ownership		67	
Alcohol use		48	
Currently smoking		39	
Healthy Eating Index	64.6 ± 0.4		0.0 – 90.0
METs	1.0 ± 0.0		0.0 – 4.2
Waist Circumference	102.3 ± 2.4		72.0 – 153.8
Body Mass Index	32.0 ± 0.5		17.5 – 57.9
Everyday Unfair Treatment	1.6 ± 0.0		0.0 – 3.6
Block Group (Level 3) (n= 56)			
Percent poverty	31.3 ± 10.9		7.8 – 54.3
Poverty quartile 1 (0–20%)		18	
Poverty quartile 2 (21–30%)		29	
Poverty quartile 3 (31–40%)		32	
Poverty quartile 4 (>40%)		21	

TABLE 2

Waist Circumference Regressed on Neighborhood Poverty and Everyday Unfair Treatment

	Model 1		Model 2		Model 3	
n= 157	**B**	**SE**	**B**	**SE**	**B**	**SE**
Intercept	102.6	0.9	102.6	0.4	102.6	0.4
Level 2 (block group)						
Everyday Unfair Treatment					−1.61	2.2
Poverty Quartile 2 (21–30%)	9.6**	2.7	3.8**	1.6	3.6**	1.7
Poverty Quartile 3 (31–40%)	8.3**	2.7	3.7**	1.6	3.6**	1.7
Poverty Quartile 4 (>40%)	7.7*	3.4	3.15	1.7	3.6**	2.1
Level 1 (individual)						
Everyday Unfair Treatment					2.4**	1.0
sigma square	22.34	2.53	16.55	2.09	16.59	2.11
tau pi	169.51	23.39	23.88	4.41	22.28	4.27
tau beta	0.10	11.01	0.05	1.97	0.27	1.97

Note. Control variables include individual age, gender, race/ethnicity, education, poverty-to-income categorization, marital status, car ownership, home ownership, alcohol use, current, never, or former smoker, modified-healthy eating index, and METs. Models 2 and 3 adjusts for BMI

*
0.05,

**
<0.05,

***
≤0.01