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Associations between neighborhood effects and physical activity, obesity, and diabetes: The Jamaica Health and Lifestyle Survey 2008

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Abstract

Objective: To examine the impact of neighborhood disorder, perceived neighborhood safety, and availability of recreational facilities on prevalence of physical activity (PA), obesity, and diabetes mellitus (DM).

Study Design and Setting: Multilevel analyses were conducted among 2,848 respondents from the 2007–08 Jamaica Health and Lifestyle Survey. Neighborhood effects were based on aggregated interviewer responses to systematic social observation questions. Mixed-effect logistic regression models were created to assess the relationship between neighborhood indicators and DM and the modifiable risk factors PA and overweight/obesity.

Results: There was significant clustering in PA levels of 20 minutes at least once per week (intraclass correlation coefficient [ICC] = 10.7%), low/no PA (ICC = 7.22%), diabetes (ICC = 5.44%), and obesity (ICC = 3.33%) across neighborhoods. Greater levels of neighborhood disorder, home disorder, and counterintuitively recreational space availability were associated with higher levels of low/no PA among women. There was significant interaction by sex between neighborhood infrastructure and overweight/obesity with a significant association in men (odds ratio [OR] = 1.16; 95% confidence interval [CI] = 1.05, 1.28) but not women (OR = 1.01; 95% CI = 0.95, 1.07).

Conclusion: Differences in PA and obesity-related outcomes among Jamaicans may be partially explained by characteristics of the neighborhood environment and differ by sex. Future studies must be conducted to determine the mechanistic pathways through which the neighborhood environment may impact such outcomes to better inform prevention efforts.

Keywords: Neighborhood effects; Physical activity; Diabetes; Obesity; Multilevel modeling; Developing country

1. Introduction

The increasing prevalence of diabetes mellitus (DM) worldwide is thought to be a result of rising obesity and physical inactivity [1]. DM, obesity, and associated comorbidities are a major threat to public health and pose a significant economic burden in both developing and developed countries [2–5]. Considerable success in decreasing morbidity from chronic noncommunicable diseases such as DM can be attributed to better treatment of these conditions—primarily through pharmacological agents. However, health promotion activities that address underlying causes of these conditions, such as obesity and reduced physical activity (PA), have been effective and are necessary. Social factors are thought to be important determinants of risk, and efforts to understand and address them must also be intensified to stem the worsening epidemic of DM and obesity [6,7]. The 2007–08 Jamaica Health and Lifestyle Survey II (JHLS II) found the following prevalences among 15–74-year-old Jamaicans: DM was 8% (standard error [S.E.], 0.6%) (females, 9.3% [S.E., 0.6%]; males, 6.4% [S.E., 1.0%]) and obesity 25% (S.E., 1.2%) (females, 37% [S.E., 1.5%]; males, 12% [S.E., 1.7%]), respectively [8]. The prevalence of low/no levels of PA was 45% (S.E., 1.5%) (females, 62% [S.E., 1.6%]; males, 28% [S.E., 2.0%]) [8].

The Jamaican data reported prevalence of these outcomes at both the national and parish level and whether survey participants resided in urban vs. rural areas. No significant differences were detected at these geographical

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What is new?

- This is the first national survey in the Caribbean to examine neighborhood determinants of physical activity (PA), measures of adiposity, and diabetes mellitus (DM) within a multilevel framework.
- There was significant clustering in PA, overweight/obesity, and DM across Jamaican neighborhoods with neighborhood characteristics having a greater effect in women.
- Greater levels of neighborhood disorder, home disorder, and counterintuitively recreational space availability were associated with higher levels of low/no PA among women.
- Better levels of neighborhood infrastructure were associated with overweight/obesity in men.
- The implications of these findings include the need to further understand the upstream factors leading to clustering and associations observed.
- Public health efforts to increase PA and reduce both overweight/obesity and DM should include targeted neighborhood-level interventions.

levels [8]. However, very little is known about the variability of these health outcomes in Jamaica at the levels of smaller geopolitical units, such as constituencies or enumeration districts (EDs). Researchers have recognized that the neighborhood may contribute negatively or positively to an individual's health and health-related behaviors.

Studies in the United States [9,10], Canada [11–13], Australia [14,15], and Europe [16,17] have documented geographic variability in PA, obesity, and DM. There are also studies that have explored whether associations exist between the built environment and PA [12,18–21]. Greater neighborhood disorder has been significantly associated with less PA [22,23]. However, the findings are less consistent regarding an association of the availability of recreational spaces/other spaces or play areas with PA [12,18,24,25]. Multilevel conceptual models and statistical techniques have facilitated social scientists and epidemiologists studying the effects of neighborhoods on an individual's health. We are unaware of research from nationally representative samples from developing countries, which have examined clustering of PA, obesity, and DM at neighborhood level. We hypothesize that within Jamaica, there is significant variability in these outcomes at the smaller geopolitical levels.

The purpose of our analysis was to examine the variability in PA, obesity, and DM across small geopolitical units known as EDs in Jamaica using data from the JHLS II. Among other things, these outcomes may be influenced by neighborhood characteristics, such as access to open spaces and neighborhood disorder [22,26,27]. We also sought to explore whether home disorder, perceived safety, and neighborhood measures, such as neighborhood infrastructure and disorder, availability of recreational areas/spaces/playing fields (including whether they were within walking distance), were associated with these behavioral and health outcomes within a multilevel framework.

2. Methods

2.1. Design

Data for this study came from the JHLS II, a cross-sectional interviewer-administered nationally representative survey. Additional details on the study design, sampling methodology, and recruitment process are documented in the full technical report [8]. The home addresses of participants were geographically linked to EDs within each parish. An ED is the smallest geographical unit into which Jamaica is divided to facilitate data collection for censuses and surveys [28]. The results presented are from secondary analysis of sociodemographic characteristics, prevalence of DM, obesity, PA, fruit and vegetable consumptions, perceptions of safety, objectively measured height, weight, waist circumference, blood pressure, fasting blood glucose (FBG), and fasting total cholesterol, and interviewer perception of the community and home environment.

2.2. Sample

The study analyzed data from 2,848 participants ages 15–74 years old between November 2007 and March 2008. Recruitment was conducted by random selection of clusters (EDs) using a probability proportional to the size of the population within parishes [29]. The interviewers received extensive training in recruitment, questionnaire administration, anthropometry, and collection of biomedical specimen for blood glucose via the fingerprick method.

2.3. Measures (individual level)

Data from the JHLS II were used to characterize individual-level measures. This included sociodemographic data, such as sex, age, educational attainment, income, occupation and location of residence, fruit and vegetable consumptions, perception of safety, and the interviewer's assessment of the quality of the respondent's home environment (home disorder score). Fruit and vegetable consumptions were defined as high if the respondent reported eating at least one serving of fruit and one serving of vegetables per day, and low otherwise. Perception of safety was determined by asking each participant how safe he or she felt to walk in the community. Scores ranged from 1 (very safe) to 5 (very dangerous). The interviewers' assessments of the quality of the respondents' home environment were a summation of scores given to the characteristics of the home. Home disorder was rated from 1 (excellent) to 4 (poor) with higher scores representing greater disorder in the home. The individual components of the score were physical condition of home, internal cleanliness of the home, physical condition of the furnishings, and external appearance of the home (Cronbach alpha = 0.96).

2.4. Physical activity

Questions on work and leisure-time PA level from a locally developed questionnaire were used to classify persons into the following three PA level categories: high/moderate, low, and inactive/no activity. The high/moderate PA level participants were those whose PA increased breathing and heart rate, lasted at least 20 minutes, and was done greater than twice weekly. Low PA level participants were those whose PA increased breathing and heart rate, lasted at least 20 minutes, and was done one or two times weekly. Inactivity was defined in persons who engaged in PA of the type previously described less than once per week.

2.5. Obesity

Obesity-related outcomes included objective measurements to ascertain overweight or obesity status (defined as body mass index 25–29.99 and $\geq$30 kg/m^2, respectively).

2.6. Diabetes mellitus

DM was defined as FBG of $\geq$7.0 mmol/L or if participant reported being on medication for DM. Measured fasting capillary glucose was converted to the equivalent fasting plasma glucose using the formula, "plasma glucose = 0.102 + 1.066 × capillary glucose" as recommended by the European Association for the Study of Diabetes guidelines [29].

2.7. Neighborhood-level measures

"Neighborhood" was defined as an ED, which is defined as a geographical area to be enumerated by a single enumerator and consisting of up to 400 dwelling places. Neighborhood-level measures were based on aggregated interviewer responses for each subject or household in the survey to obtain a marker at the neighborhood level. Measures included a summated scale of the interviewer's assessment of the neighborhood's infrastructure (neighborhood infrastructure score) and the interviewer's assessment of the quality of the neighborhood (neighborhood disorder score). The interviewer's assessment of the *neighborhood's infrastructure* was a summation of scores indicative of the presence (1) or absence (0) of the following in the neighborhood: paved roads, sidewalks, electricity supply to homes, telephone lines to homes, street lights, clean streets, and recreation areas. Thus, higher values indicated neighborhoods with more favorable characteristics (Cronbach alpha = 0.75). Similarly, interviewer's assessment of the *quality of the neighborhood* (*neighborhood disorder*) summed scores given to the condition of the homes, condition of the streets, condition of the yards, the amount of noise, and the air quality in the neighborhoods. Scores for each variable ranged from 1 (excellent) to 4 (poor) so that higher values of the summed scores indicated poorer quality (Cronbach alpha = 0.89). Both neighborhood infrastructure and disorder scores were aggregated to the ED level to obtain a marker of these characteristics at the neighborhood level.

Recreational areas/playing fields/opens spaces availability and whether they were *within walking distance* of the home were assessed by interviewers in separate questions. Scores for availability were 0 (no) and 1 (yes). Scores for whether these facilities were within walking distance of the participant's home were scored 1 (yes) and 2 (no). In both questions, responses when the interviewer was unable to assess or was unsure were excluded from the analysis.

2.8. Statistical analysis

Weighted summary statistics—means and proportions—with 95% confidence intervals (CIs) for the outcome, explanatory, and confounding variables were used to describe the study population of 15–74-year-old Jamaicans. The sampling design weight was calculated as the product of the inverse of the probability of selecting a primary sampling unit and the inverse of the probability of selecting a household. Poststratification weights were calculated as the number of persons in the Jamaican population of 15–74 year olds represented by each individual in the sample within 5-year age–sex categories. These poststratification weights were used to adjust the raw sampling design weights as per algorithms within the *svyset* program of STATA Version 10.1. Having specified the strata, EDs, and household (individual) as the different stages of analysis and also the different weight variables, the software's survey data analysis algorithms produced weighted estimates of the parameters and variance estimates that appropriately accounted for the variability between and within the groups defined by the different stages of selection. Linearized (robust) variance estimation was used to quantify variability of parameter estimates.

Multilevel analysis using mixed-effects logistic regression models provided intraclass correlation coefficients (ICCs), which estimated the degree of homogeneity within the neighborhood in terms of the amount of variance in PA, obesity, and DM potentially explained at the neighborhood level. Such models allow for partitioning variance estimates at multiple levels, the EDs from which participants were selected and the individuals within EDs, thereby accounting for variance in individual-level outcomes that can be attributed to differences between neighborhoods. An ICC at or above 2% is suggestive of a potential higher level effect (eg, neighborhood) and worth examining in a multilevel framework [30]. Logistic regression that accounted for the multistage survey design was used to quantify the impact of neighborhood infrastructure, neighborhood and home disorders, and availability of recreational facilities on these outcomes providing odds ratios (ORs) and 95% CIs, while controlling for age, sex, fruit and vegetable consumptions, and individual markers of home and neighborhood infrastructure and disorder. With parish of residence as the strata, EDs were selected from within parishes, households were selected from within EDs, and individuals selected from within households, yielding a multistage survey.

Confounders were examined based on their relation to the outcome and exposure of interest, as well as whether they changed the effect estimate by more than 10% when controlled. The ICC for binary models was calculated by following Snijders formula based on an underlying continuous variable with $V_{\text{individual}} = \Pi^2/3$ [31]. Snijders and Bosker [31] have also developed formulae to estimate power for hierarchical models. General guidelines addressing minimum sample sizes for multilevel models include a minimum ratio of 6–10 individuals (level 1) to aggregates (level 2). Kreft and De Leeuw [32] suggested a "30/30 rule" so that researchers should strive for a sample of at least 30 groups with 30 individuals per group. With the JHLS II having 62 EDs with an average of 32 individuals per ED, there was sufficient power for the proposed multilevel analyses, including potential subgroup analyses. All analyses were conducted in STATA, version 10.1.

2.9. Ethics

Ethical approval was obtained from the ethical committees of the Ministry of Health, Jamaica, and the University Hospital of the West Indies. Written informed consent was obtained in person by research staff.

3. Results

Table 1 describes the weighted summary statistics for the Jamaican population between 15 and 74 years old. The mean age of participants was 36.9 (±0.1) years. Motor vehicle ownership was significantly higher in men than women ($P < 0.001$). Women were significantly more likely to report low/no PA (45% vs. 28%), be overweight/obese (52% vs. 38%), and have DM (8% vs. 6%) compared with men. Women had lower perception of safety scores (ie, viewed neighborhood as more dangerous) and also had statistically significantly higher neighborhood and home disorder scores. There were no significant differences reported between the sexes for recreational space availability or whether the recreational space was within walking distance.

There was significant clustering in PA, overweight/obesity, and DM across neighborhoods in Jamaica. Twenty minutes of PA, at least once per week (ICC = 10.7%), accounted for the greatest proportion of the variance explained at the neighborhood level, followed by low/no PA levels (ICC = 7.22%), DM (ICC = 5.44%), and overweight/obesity (ICC = 3.33%).

3.1. Neighborhood characteristics and PA

Tables 2–4 present combined and sex-specific results of the mixed-effects logistic regression models. For the combined results (adjusted for average community score, fruit and vegetable consumptions, age, and sex), increased levels of neighborhood disorder (OR = 1.05; 95% CI = 1.02, 1.07), home disorder (OR = 1.03; 95% CI = 1.004, 1.05), and recreational space availability (OR = 1.24; 95% CI = 1.04, 1.48) were significantly associated with low/no PA. Sex-specific results of the relationship between neighborhood disorder score and low/no PA revealed a significant association among females (OR = 1.06; 95%

Table 1. Weighted summary statistics (95% CI) for 15–74-year-old Jamaicans (JHLS II, 2008)

Variable	Total (n = 2,848)	Men (n = 891)	Women (n = 1,957)
Mean age (yr)	36.9 (36.8, 37.0)	36.9 (36.8, 37.1)	36.9 (36.8, 37.0)
Low/no physical activity (%)***	45.3 (42.4, 48.2)	28.0 (23.9, 32.0)	61.9 (58.7, 65.2)
Overweight/obese (%)***	51.7 (49.1, 54.3)	38.2 (33.9, 42.6)	64.6 (61.8, 67.4)
Diabetes (%)*	7.9 (6.7, 9.0)	6.4 (4.5, 8.3)	9.3 (8.0, 10.5)
Mean fasting glucose (mmol/L)	4.2 (4.1, 4.3)	4.2 (4.0, 4.3)	4.1 (4.0, 4.2)
Possessions owned			
≤6 items	38.0 (34.4, 41.7)	34.3 (29.4, 39.2)	41.6 (37.9, 45.3)
7–9 items	31.2 (28.7, 33.6)	30.7 (27.0, 34.4)	31.6 (29.1, 34.1)
10–16 items	30.8 (27.1, 34.5)	35.0 (30.2, 39.8)	26.8 (22.8, 30.7)
Motor vehicle ownership (%)***	28.0 (24.5, 31.6)	36.2 (31.3, 41.1)	20.2 (16.8, 23.6)
Perception of safety score*	2.2 (2.1, 2.3)	2.1 (2.0, 2.2)	2.2 (2.1, 2.4)
Neighborhood infrastructure score	5.0 (4.8, 5.3)	5.1 (4.9, 5.3)	5.0 (4.8, 5.2)
Neighborhood disorder score***	11.4 (10.9, 12.0)	11.1 (10.5, 11.7)	11.8 (11.2, 12.3)
Home disorder score*	8.8 (8.4, 9.2)	8.6 (8.1, 9.1)	9.0 (8.6, 9.4)
Recreational space available (%)	62.2 (55.3, 69.0)	62.4 (54.9, 70.0)	61.9 (54.9, 69.0)
Recreational space in walking distance (%)	49.1 (41.2, 56.9)	51.3 (42.8, 58.7)	47.0 (38.8, 55.1)

Abbreviations: 95% CI, 95% confidence interval; JHLS II, Jamaica Health and Lifestyle Survey II.
*$P < 0.05$, ***$P < 0.001$.

Table 2. Unadjusted and adjusted odds ratios for PA, overweight/obesity, and diabetes (males and females)

Variable	Low/no PA		Overweight/obese		Diabetes	
	Unadjusted	Adjusted	Unadjusted	Adjusted[a]	Unadjusted	Adjusted[a]
Neighborhood infrastructure	1.03 (0.97–1.08)	1.02 (0.98–1.07)	1.04 (0.99–1.09)	1.06 (1.01–1.11)	1.01 (0.94–1.09)	1.02 (0.95–1.10)
Neighborhood disorder score	1.06 (1.03–1.09)***	1.05 (1.02–1.07)***	0.98 (0.96–1.01)	0.98 (0.95–1.01)	0.99 (0.95–1.03)	0.99 (0.95–1.03)
Home disorder score	1.03 (1.001–1.05)*	1.03 (1.004–1.05)*	0.95 (0.92–0.97)***	0.95 (0.93–0.97)***	0.98 (0.94–1.02)	1.00 (0.96–1.03)
Recreational space in walking distance	1.10 (0.90–1.36)	1.12 (0.94–1.34)	1.03 (0.86–1.23)	1.11 (0.93–1.31)	0.99 (0.74–1.32)	1.12 (0.86–1.45)
Recreational space availability	1.22 (1.01–1.49)*	1.24 (1.04–1.48)*	0.93 (0.78–1.11)	0.94 (0.78–1.13)	0.98 (0.74–1.29)	1.01 (0.77–1.32)
Perception of safety	1.01 (0.94–1.10)	1.00 (0.93–1.08)	0.99 (0.95–1.03)	0.95 (0.88–1.03)	0.96 (0.86–1.08)	0.99 (0.88–1.11)

Abbreviation: PA, physical activity.

*$P < 0.05$, ***$P < 0.001$.

[a] Adjusted model includes fruit and vegetable consumptions, age, and sex as level 1 covariates and enumeration district as a level 2 covariate.

CI = 1.03, 1.09) but not males (OR = 1.02; 95% CI = 0.96, 1.07); however, there was no statistically significant interaction by sex. Similarly among females, a one-unit increase in home disorder score was associated with a 4% increase ($P < 0.01$) in the odds of low PA/inactivity (OR = 1.04; 95% CI = 1.01, 1.07); however, a one-unit increase in recreational space availability was associated with a 28% increase ($P < 0.05$) in the odds of low/no PA (OR = 1.28; 95% CI = 1.05, 1.57). In males, there was no statistically significant association of either home disorder (OR = 1.00; 95% CI = 0.95, 1.05) or recreational space availability (OR = 1.13; 95% CI = 0.78, 1.66) with low/no PA. There was also no significant effect modification by sex in any of these relationships.

3.2. Neighborhood characteristics and overweight/obesity

There was statistically significant interaction between sex of participant and neighborhood infrastructure score in their relationship to occurrence of overweight/obesity. Among females, there was no association between neighborhood infrastructure score and overweight/obesity (OR = 1.01; 95% CI = 0.95, 1.07). However, among males, improved neighborhood infrastructure increased the odds of overweight/obesity by 16% (OR = 1.16; 95% CI = 1.05, 1.28; $P < 0.01$). Increased levels of home disorder when adjusted for fruit and vegetable consumptions, age, sex, and the aggregated level of home disorder for the neighborhood were significantly associated with lower levels of overweight/obesity (OR = 0.95; 95% CI = 0.93, 0.97). Sex-specific results in Tables 3 and 4 revealed a significant relationship between home disorder and overweight/obesity among both females (OR = 0.96; 95% CI = 0.0.94, 0.99) and males (OR = 0.92; 95% CI = 0.87, 0.97).

3.3. Neighborhood characteristics and diabetes

There were no statistically significant associations between neighborhood disorder or availability of recreational facilities and DM. The models also showed no association of fruit and vegetable consumptions with overweight/obesity or DM. Neither low/no PA nor overweight/obesity were found to act as mediators in the relationships between the neighborhood effect variables and DM.

Table 3. Unadjusted and adjusted odds ratios for PA, overweight/obesity, and diabetes (females)

Variable	Low/no PA		Overweight/obese		Diabetes	
	Unadjusted	Adjusted[a]	Unadjusted	Adjusted[a]	Unadjusted	Adjusted[a]
Neighborhood infrastructure	1.00 (0.95–1.06)	1.00 (0.95–1.06)	1.01 (0.96–1.07)	1.01 (0.95–1.07)	1.04 (0.96–1.13)	1.04 (0.95–1.13)
Neighborhood disorder score	1.06 (1.03–1.09)***	1.06 (1.03–1.09)***	0.97 (0.94–0.997)*	0.98 (0.95–1.01)	0.97 (0.93–1.01)	0.99 (0.95–1.03)
Home disorder score	1.04 (1.01–1.07)*	1.04 (1.01–1.07)**	0.95 (0.92–0.98)**	0.96 (0.94–0.99)*	0.98 (0.94–1.02)	1.01 (0.96–1.05)
Recreational space in walking distance	1.15 (0.93–1.41)	1.14 (0.93–1.41)	1.06 (0.86–1.30)	1.08 (0.88–1.34)	0.94 (0.71–1.25)	0.98 (0.72–1.33)
Recreational space availability	1.14 (0.78–1.66)	1.28 (1.05–1.57)*	1.01 (0.82–1.25)	1.00 (0.80–1.24)	1.04 (0.78–1.40)	1.05 (0.77–1.43)
Perception of safety	0.97 (0.90–1.06)	0.98 (0.90–1.07)	0.89 (0.82–0.97)*	0.91 (0.83–1.00)	0.93 (0.82–1.05)	0.97 (0.85–1.11)

Abbreviation: PA, physical activity.

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

[a] Adjusted model includes fruit and vegetable consumptions and age as level 1 covariates and enumeration district as a level 2 covariate.

Table 4. Unadjusted and adjusted odds ratios for PA, overweight/obesity, and diabetes (males)

	Low/no PA		Overweight/obese		Diabetes	
Variable	Unadjusted	Adjusted[a]	Unadjusted	Adjusted[a]	Unadjusted	Adjusted[a]
Neighborhood infrastructure	1.06 (0.96–1.18)	1.08 (0.98–1.19)	1.11 (1.01–1.22)*	1.16 (1.05–1.28)**	0.93 (0.80–1.07)	0.99 (0.85–1.16)
Neighborhood disorder score	1.02 (0.97–1.07)	1.02 (0.96–1.07)	1.00 (0.95–1.05)	0.99 (0.94–1.05)	1.00 (0.93–1.09)	1.00 (0.91–1.08)
Home disorder score	1.00 (0.95–1.05)	1.00 (0.95–1.05)	0.93 (0.88–0.97)**	0.92 (0.87–0.97)**	0.97 (0.90–1.06)	0.97 (0.89–1.05)
Recreational space in walking distance	1.05 (0.72–1.51)	1.07 (0.74–1.54)	1.11 (0.78–1.57)	1.15 (0.80–1.65)	1.43 (0.81–2.52)	1.61 (0.89–2.93)
Recreational space availability	1.30 (1.06–1.58)*	1.13 (0.78–1.66)	0.84 (0.58–1.20)	0.84 (0.58–1.23)	0.92 (0.52–1.65)	0.91 (0.49–1.67)
Perception of safety	1.06 (0.90–1.25)	1.07 (0.91–1.26)	1.01 (0.86–1.19)	1.05 (0.89–1.24)	0.82 (0.79–1.31)	1.06 (0.81–1.40)

Abbreviation: PA, physical activity.
$*P < 0.05$, $**P < 0.01$.
[a] Adjusted model includes fruit and vegetable consumptions and age as level 1 covariates and enumeration district as a level 2 covariate.

4. Discussion

A better understanding of the factors that contribute to physical inactivity, overweight/obesity, and DM would facilitate the identification of approaches to arrest the rising levels of these outcomes and risk factors in developing countries, such as Jamaica. In this study, we examined (1) whether variability existed in PA, overweight/obesity, and DM across neighborhoods in Jamaica and (2) the impact of perceived safety, home disorder, neighborhood disorder, and recreational facility availability on these outcomes. Our study suggests that a portion of the total variability in these outcomes was because of variations between neighborhoods at the level of EDs in Jamaica. Using multilevel modeling, we also showed that significant positive associations exist between neighborhood disorder, home disorder, and recreational space availability with low/no levels of PA among women, between neighborhood infrastructure and being overweight/obese in men, and significant inverse relationships between home disorder and being overweight/obese in both sexes.

As stated earlier, there is now much research evidence documenting geographic variations in a wide range of health outcomes between sexes and among different age groups and nationalities in developed countries [9–13,15–17]. The suggestion is that there are two possible explanations for the geographic variations; compositional and contextual. To elaborate, differences could be either related to the kinds of people who live in a particular area (compositional) or something to do with the physical and social context, often referred to as the built environment [33–36].

In our study, neighborhood-level variation contributed greatest to levels of low/no PA, followed by DM, and being overweight/obese. It is possible that PA as a behavior is influenced more by neighborhood influences such as (1) availability and/or access to physical infrastructure such as recreational facilities/open spaces/sidewalks and (2) social processes at the neighborhood level, such as social capital and collective efficacy [37,38]. On the other hand, overweight/obesity may be more influenced by individual-level factors, such as age, genetics, disease presence, dietary preferences, body size perception, and perceived barriers to exercise. For example, studies have documented that a high percentage of both Jamaican women and men who are overweight do not consider themselves to be so [8,39,40].

With regard to levels of low/no PA, increased neighborhood disorder, home disorder, and recreational space availability emerged as significant in the models after controlling for other individual-level covariates. Our study revealed an inverse association between neighborhood disorder, with greater disorder related to lower levels of PA, but other studies that have examined this relationship had mixed findings. For example, a study examining youth PA among Chicago neighborhoods in the United States [23] and one among middle-aged Australians living in Brisbane had inverse direction of association between neighborhood disorder and levels of PA [15]. However, in the latter study, the association was direct when it came to walking for transport. One study found that adolescents' reports of the aesthetics of their neighborhoods (ie, there are many interesting things to look at while walking) were positively associated with their self-reported PA [41]. On the other hand, Ross and Mirowsky [22] found that neighborhood disorder was associated with increased propensity to walk, despite individual levels of fear, and suggested this was perhaps reflective of social norms, such as hanging out at street corners and walking to visit others down the road, inability to afford a car, and walking to the corner store. Direct comparison with these studies is not possible, given differences in definition and categorization of levels of PA, as well as populations, definitions of neighborhood, and neighborhood characteristics.

We are unsure why greater home disorder and counterintuitively greater recreation space availability were significantly associated with low/no PA levels among women. In the case of home disorder, it is possible that this index is a proxy for poverty. It is also possible that the PA questions in the JHLS II failed to adequately capture routine PA associated with housework, done more by women than men in the Jamaican context. Our finding that women living in areas with recreational spaces available were more likely to be classified as having low PA may also be related to the type and quality of the facilities and perceptions of safety in using them. Anecdotally, many of these recreational spaces in communities are not woman- and child friendly, but this was not assessed in our study. We recommend that future national surveys or complementary studies be conducted to assess the users and their PA patterns, as well as the physical characteristics of these recreational spaces.

We were unable to find any comparable study that examined the association between home disorder and overweight/obesity. As stated previously, our findings of a significant negative association are suggestive that home disorder could be a proxy for poverty. Several studies [2,3] have shown that the prevalence of overweight/obesity is lower among poorer persons compared with those of wealth within developing countries. However, results reported elsewhere from this survey [8] reveal higher levels of obesity/overweight among persons of lower socioeconomic status in keeping with results from other cross-sectional studies done in middle-income countries, the poverty-obesity paradox [42,43]. We are unclear why better neighborhood infrastructure is associated with obesity/overweight in men but not women. We have reported similar differences in sex-specific outcomes for diabetes control in the JHLS II [44]. Men of higher socioeconomic status had worse diabetes control with an inverse relationship for women. We believe that this additional finding from a neighborhood perspective supports further exploration of these obesity-related outcomes from a gender perspective.

Contrary to our hypothesis, we found no associations between perception of safety, availability of recreational spaces within walking distance, and the outcomes PA, overweight/obesity, and DM. In the case of perception of safety to walk, it is quite possible that associations may have been revealed if daytime or nighttime safety had been explored. With the exception of the presence of clean streets, the quality of other neighborhood features such as recreational facilities was not ascertained in our study, and therefore, our specific measure of recreational availability within walking distance may have been too general to discern any impact on our outcomes of interest.

Despite important findings, this study is not without limitations, including the use of cross-sectional data with no causal or temporal examinations. The neighborhood was defined as the ED out of necessity, based on the data available from the survey [8]. Many neighborhoods are quite heterogeneous and represent aggregations of populations comprising differing geographical sizes and may have failed to correctly capture important geographic effects. There are many informal housing settlements, making it almost impossible to geocode existing data, given the lack of unique addresses for many of those households. In addition, there are no validated tools that could have been applied to capture specific neighborhood indicators, such as the physical and social environments, as it relates to health within the developing country context. The built environment measures were not defined according to any regional or international classification system. Neighborhood measures were not correlated with objective measures, such as crime rates and graffiti presence. Additionally, responses on much of the neighborhood measures were based on interviewer perception, which may be divergent from the participants' and which were subjective in their own right. We recommend that future surveys capture (1) both participant and interviewer perceptions and (2) interinterviewer reliabilities to determine preservation of rank order in the assessments. PA was based on self-reported data, subject not only to recall bias but also differing significantly from objective measures [45].

To our certain knowledge, this is the first study in Jamaica and the wider Caribbean to examine determinants of PA, measures of adiposity, and DM within a multilevel framework. The variables included in the neighborhood indices developed were chosen based on established and perceived associations with health and availability within the JHLS II. However, the neighborhood measures were not subjected to internal validation procedures. Because of the nature of the JHLS II, we were unable to control for important variables related to the food environment and important social processes such as social cohesion. Future national surveys should be modified, and/or supplementary studies conducted to collect data that will better facilitate the qualitative evaluation of perception of the neighborhood environment and its impact on the adoption of positive lifestyle-related behaviors.

These results offer new empirical evidence on the association of neighborhood effects with chronic diseases and their risk factors in Jamaica and may offer new insights to other developing countries within and outside the Caribbean. Additionally, the findings have generated new hypotheses that pave the way for further examining neighborhood determinants and mechanistic pathways through which neighborhood influences health outcomes in such an environment. Specifically, we believe these findings are suggestive of the possible influence of undetermined gender roles and behaviors, sociocultural norms, psychological processes, and characteristics of the built environment on these outcomes. Improving the quality of data collected will be a first step and must include the creation and validation of quantitative and qualitative measures appropriate for the Jamaican context. With obvious geographical variation in PA, obesity, and DM among Jamaican adults, public health efforts must expand beyond individual-level interventions to target cost-effective neighborhood interventions at the primary care level of health service delivery, health promotion/education with strong community-level engagement, and policy changes. Any metrics or measures developed should serve as a useful guide for future studies not only in developing countries but also in those developed ones with subpopulations possessing similar compositional and contextual characteristics.

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