

PAPER

Higher income is more strongly associated with obesity than with obesity-related metabolic disorders in Jamaican adults

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OBJECTIVE: This study compares how income is related to obesity vs two obesity-related cardiovascular disease (CVD) risk factors—diabetes and hypertension—in adults from Jamaica.

DESIGN: A cross-sectional population-based survey was used. In total, 847 men and 1249 women aged 25–74 y were randomly recruited from a periurban area in 1993–1998.

MEASUREMENTS: Trained interviewers measured anthropometry and blood pressure, obtained fasting blood and collected self-reported data on income and disease history.

RESULTS: Income was strongly and positively associated with obesity in men. In women, obesity levels were high even among the very poor, and the income gradient was more moderate. Although obesity—and particularly central fatness—was strongly associated with diabetes and hypertension prevalence, income was not significantly related to these disorders.

CONCLUSIONS: Future research in developing countries should independently explore associations between income and obesity vs obesity-related disorders, and identify factors that explain any disparities.

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Introduction

In developing countries undergoing rapid socioeconomic change, lifestyle changes such as increased sedentarism and rising consumption of fats and refined carbohydrates are thought to be fueling an epidemic of obesity.^{1,2} In the past, studies in developing countries generally found higher levels of obesity in upper socioeconomic status (SES) groups, suggesting that these lifestyle changes were largely adopted in relatively well-off groups.^{3,4} However, recent studies in several middle-income countries have reported dramatic increases in obesity in low-SES groups, attenuating the SES-obesity association.^{5–7} Studies in other middle-income countries are needed to assess the extent to which obesity is increasing in low-income groups. A better understanding of the changing SES distribution of obesity may also

provide insights on the sociocultural etiology of the obesity epidemic.

Rising obesity prevalence in developing countries is of particular concern because of the strong link between obesity—in particular abdominal obesity—and metabolic disorders associated with cardiovascular disease (CVD) risk, such as hypertension, diabetes and dyslipidemia.^{8–10} Increasing obesity in low-SES strata may well contribute to increases in these disorders among the poor. Since few recent studies have examined relationships between SES and CVD risk factors in developing countries, however, it is uncertain to what extent emerging obesity patterns reflect the distribution of these disorders.^{11–15}

This paper examines how income is related to prevalent obesity and two CVD risk factors—diabetes and hypertension—among adults in Jamaica, a middle-income developing country in the Caribbean. We describe the income distributions of both general and central obesity. Several studies have found central obesity to be a better predictor of chronic disease risk than measures based on body mass index

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(BMI) alone.^{16,17} Thus, it is important to evaluate whether the SES distribution of more generalized overweight and obesity adequately reflects the distribution of excessive central fat distribution. In addition to obesity, we describe the distribution of hypertension and diabetes across income strata, and compare the direction and magnitude of these patterns with the distribution of various indices of obesity. Finally, we estimate associations between different types of obesity and prevalence of these disorders, and use stratified analysis to examine whether there is evidence of disproportionately high adverse effects among the poor.

Subjects and methods

Data for this analysis come from an ongoing survey initiated as part of the International Collaborative Study on Hypertension in Blacks (ICSHIB). A stratified sample of men and women in four age groups (25–34, 35–44, 45–54 and 55–74 y) was recruited from randomly selected census enumeration areas in and around Spanish Town, a periurban area neighboring the capital city of Kingston. A total of 2096 subjects were recruited between January 1993 and January 1998. The response rate was 61%. Further details on the design have been published previously.^{18,19}

All data were collected by trained staff using standardized procedures. Height (to the nearest 0.1 cm) and weight (to the nearest 0.1 lbs) were measured without shoes and with light clothing. Digital scales were calibrated daily. Weight was converted to kilograms by dividing by 2.2046. Circumferences (hip and waist) collected as prescribed by Lohman *et al*²⁰ were duplicated and the mean (in cm) was used. If measures differed by >0.5 cm, a third circumference was obtained and the mean of the two closest measures was used.

BMI was used as an indicator of general excess in total body fat. Standard cutpoints (weight (kg)/height² (meters)) were used to define general overweight (25–<30) and obesity (≥ 30).²¹ Underweight (BMI < 18.5 kg/m²; 6.5% of men and 4.8% of women) and normal weight subjects were pooled since separating this group had little effect. As few men were obese ($n = 60$ with income data), overweight and obesity were combined in most models; when cell sizes were sufficient, supplementary analysis was used to verify that patterns for overweight and obese men were similar. Waist circumference (WC) provides an index of abdominal fatness, while waist-to-hip ratio (WHR) measures the ratio of upper body fat to lower body fat and muscle mass. Large WC was defined as >94 cm for men, and >80 cm for women;^{21,22} WHR was categorized as high if >0.94 for men and >0.80 for women.^{23–25} Incorporating action level 2 cutpoints of WC > 102 cm in men and 88 cm in women, and corresponding cutpoints of 1.02 and 0.88 for WHR did not meaningfully influence results. The use of standard cutpoints allows comparisons across countries,²⁶ although they may not maximize sensitivity or specificity for predicting risk in this population. Results were similar using continuous variables (not shown).

Obesity indices were moderately to highly correlated. The Spearman correlations between categorical variables in men were: 0.46 between overweight/obese and high WHR; 0.57 between overweight/obese and large waist and 0.66 between high WHR and large WC. In women, correlations were 0.30, 0.76, and 0.48, respectively. Although models that adjusted simultaneously for multiple indices of obesity did not have collinearity problems (variance inflation factors were <5), in some models, interactions between indices of overweight/obesity and central fatness (WHR or WC) were statistically significant, and resulted in excessive collinearity (variance inflation factors >10). Therefore, to ensure that associations with different patterns of obesity were estimated reliably, we substituted variables in which participants were crossclassified based on general overweight and central fatness (WHR or large WC). While adequate numbers had isolated overweight or overweight combined with large WC, however, nonoverweight participants with large WC were omitted as there were too few to analyze this group separately ($n = 34$ women, four men).

Diabetes (available for 91% of participants) was defined as self-reported current use of insulin or oral diabetes medication, fasting glucose levels ≥ 7.0 mmol/l, or 2-h postload glucose ≥ 11.1 mmol/l.^{27,28} Hypertension (available for 99%) was defined as current medication use, mean systolic blood pressure (SBP) ≥ 140 mm Hg, or mean diastolic blood pressure (DBP) ≥ 90 mm Hg.²⁹ Associations between income and hypertension, including treatment and awareness, have been reported previously in greater detail.³⁰

Current income category in Jamaican dollars (\leq J\$600, 601–1000, 1001–3000, 3001–6000, 6001–12000, ≥ 12000) was obtained by self-report. Category midpoints were used to deflate income to 1993 Jamaican dollars based on data from the Statistical Institute of Jamaica.³¹ Poverty was defined as monthly incomes \leq J\$3000/month, approximately the official poverty line.³² A total of 18% of participants declined to report income. There was no difference in age, sex, body composition, blood pressure or glucose measures among those with vs without income data. However, income was somewhat more likely to be missing among diabetic than nondiabetic women (24 vs 17%). In selected models, we also confirmed that an imputed income variable yielded similar findings to those presented (not shown).³⁰ In addition to imputed income, we confirmed that relationships were similar using family income data (Spearman's R with individual income = 0.78) collected from a subgroup of 997 subjects as part of an earlier substudy.³³ The validity of income was further corroborated by a strong positive association with education: 62% of subjects with ≤ 6 years of education fell below the poverty line, while 69% of subjects with college education has incomes of J\$6000 or more.

All analysis used Stata version 7.0 (Stata Corp, College Station, TX, USA). Age- and sex-adjusted means and percentages were used to describe the prevalence of obesity and each disorder across SES strata (using age groups 25–34, 35–44, 45–54 and 55–65 and 65 + y). Excluding participants

(27 men and 27 women) reporting a history of congestive heart failure, stroke or diagnosed heart disease had little or no effect, therefore these subjects were included.

Multivariate associations were estimated using logistic (binary outcomes) or multinomial regression (multilevel outcomes, eg overweight or obese vs normal weight). Variables included as confounders in multivariate models were age, education level (\leq 6th grade, any high school, any college), cigarette smoking (current, past or never), marital status (married or co-residing; widowed, divorced or separated; single and never married) and family history of hypertension or diabetes (any first-degree relative, uncertain, no). These variables changed coefficients of interest by $>15\%$ in at least some models. Selected models also included simultaneous adjustment for multiple indices of obesity. Interaction terms were defined as significant if $P < 0.15$. Results are presented as odds ratios (ORs) and 95% confidence intervals (CIs).

Results

Income and overweight/obesity

Higher income was positively associated with both general and central obesity. Income distributions were similar for different indices of obesity (Figure 1, Table 1). Among men, prevalence of various measures of obesity ranged from 4 to 10% in the poorest income group. Prevalence increased fairly linearly, peaking sharply in the highest income group. After multivariate adjustment, men with the highest incomes had four times greater odds of general obesity than the poorest men, while odds were increased two-fold in the second-highest income group (Table 2). Crossclassifying based on central and general indices of obesity suggested that income was particularly strongly related to central fatness in men. In multivariate multinomial models, ORs comparing the highest vs lowest income groups were 7.80 (CI 3.58–16.97) for overweight with high WHR, and 3.38 (CI 0.94–12.12) for high WHR alone, but only 1.14 (CI 0.57–2.30) for overweight in the absence of high WHR (referent = normal weight, normal WHR). Substituting obesity for overweight did not meaningfully change results. Similarly, there was a statistically significant four-fold higher odds of overweight with

large WC in the highest vs lowest income groups, but no difference in the odds of overweight alone.

Levels of obesity in the poorest women were several times higher than those in men; prevalence ranged from 30 to 56%, depending on the measure used. Furthermore, although obesity prevalence in women was generally higher above than below the poverty line (J\$3 K), income-related differences were more moderate than in men. Multivariate ORs comparing prevalence in women above vs below the poverty line were significant for overweight, obesity, and large WC, but not for high WHR. Moreover, unlike men, some indices peaked or reached a threshold at the poverty line: prevalence differences across the top income groups were small (Figure 1). Also in contrast to men, crossclassifying based on different indices did not suggest that income was more strongly associated with central than with general obesity. Nonpoor women had similarly increased odds of overweight combined with high WHR (adjusted multinomial OR 1.75, CI 1.21–2.53) and overweight alone (1.87, CI 1.23–2.71), but were no more likely than poor women to have isolated high WHR (0.95, CI 0.51–1.75). Results were similar when obesity was used rather than overweight (not shown), or when WC was used to characterize central fatness (multinomial OR 1.62, CI 0.96–2.71 for overweight; and 1.96, CI 1.42–2.72 for overweight with large WC, referent = normal weight and WC).

Income and diabetes/hypertension

In contrast to the strong gradient observed for obesity, income distributions of prevalent hypertension and diabetes in men were weak and nonlinear (Figure 2). As described previously, the distribution of hypertension was J-shaped: the top-income group tended to have the highest levels of hypertension, but levels were also elevated in the poorest men.³⁰ The distribution of diabetes was irregular, although levels were highest in the top-income group. After adjustment, income associations with both diabetes and hypertension were weak and nonsignificant. Comparing the highest vs lowest income groups, adjusted ORs were 1.47 (CI 0.78–2.77) for hypertension, and 1.51 (CI 0.64–3.61) for diabetes.

Among women, distributions of both diabetes and hypertension were U-shaped, although levels of diabetes peaked in the lowest rather than the highest income group (Figure 2). Although there were some significant differences in prevalence between intermediate-income groups and the groups with peak prevalence, differences in the highest vs lowest income groups were not significant (adjusted OR 0.64, CI 0.31–1.32 for diabetes; and 1.55, CI 0.87–2.76 for hypertension). Indeed, despite having relatively high levels of obesity, diabetes prevalence was lower in nonpoor than in poor women (adjusted OR 0.67, CI 0.43–1.04).

Obesity and diabetes/hypertension

Despite the lack of significant relationships with income, diabetes prevalence was strongly and significantly associated

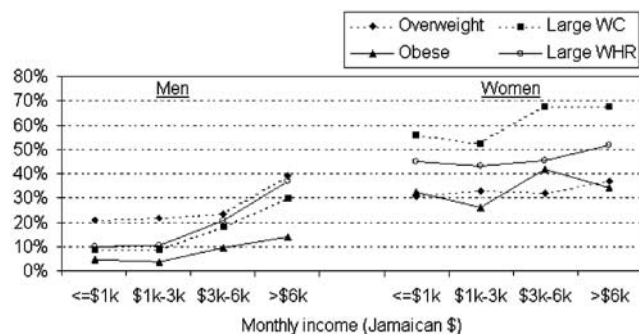


Figure 1 Age-adjusted prevalence of obesity indices by income.

Table 1 Age-adjusted distribution of body composition measures by sex and income^a

	N (% total)	Age (y)	Body mass index (BMI)		WC	WHR
		Mean (s.d.)	% Overweight	% Obese	% large	% high
Men						
All	847	46.4 (14.5)	26.4	8.9	16.5	19.7
W/income ^b	699	46.5 (14.5)	26.2	9.0	16.7	19.8
<i>Income</i>						
≤ 1000	155 (22.2%)	55.8 (15.0)	20.5	4.4	8.5	9.7
1000–3000	135 (19.3%)	47.9 (14.1)	21.5	3.6	8.5	10.4
3001–6000	205 (29.3%)	42.3 (13.3)	23.2	9.3	18.1	20.6
≥ 6000	204 (29.2%)	42.8 (12.2)	39.3	14.0	29.4	36.7
Women						
All	1249	46.1 (13.6)	32.8	33.5	59.4	45.9
W/income	1022	45.9 (13.5)	32.6	32.7	58.7	44.9
<i>Income</i>						
≤ 1000	369 (36.1%)	50.0 (14.6)	30.4	32.5	56.3	44.9
1000–3000	285 (27.9%)	44.6 (12.8)	32.7	26.1	52.7	43.2
3001–6000	243 (23.8%)	43.2 (11.8)	31.7	41.8	68.0	45.4
≥ 6000	125 (12.2%)	42.0 (11.4)	36.9	34.4	67.7	51.6

^aOverweight = BMI > 25.0 kg/m²; obese = BMI > 30.0 kg/m²; large waist circumference (WC) = > 94 cm for men, > 80 cm for women; high waist-to-hip ratio (WHR) = > 0.90 for men, > 0.80 for women. ^bW/income: among those reporting income data.

Table 2 Associations between income and overweight/obesity^a

	BMI category			
	Overweight	Obese	Large waist circumference	High waist-to-hip ratio
<i>Age-adjusted associations</i>				
Men				
<i>Income</i>				
≤ 1000 (ref)	—	—	—	—
1000–3000	1.10 (0.61–2.01)	1.00 (0.31–3.28)	1.15 (0.51–2.56)	1.16 (0.57–2.36)
3001–6000	1.46 (0.84–2.54)	2.28 (0.84–6.18)	2.63*(1.31–5.28)	2.33*(1.22–4.45)
≥ 6000	3.02*(1.75–5.20)	5.03*(1.92–13.19)	4.92*(2.50–9.70)	6.60*(3.50–12.47)
Women				
<i>Income</i>				
≤ 1000 (ref)	—	—	—	—
1000–3000	0.93 (0.64–1.36)	0.74 (0.50–1.09)	0.88 (0.64–1.22)	1.01 (0.73–1.40)
3001–6000	1.56*(1.02–2.39)	1.82*(1.20–2.76)	1.67*(1.18–2.37)	1.07 (0.76–1.51)
≥ 6000	1.46 (0.87–2.47)	1.45 (0.87–2.44)	1.58 *(1.02–2.44)	1.35 (0.88–2.07)
<i>Multivariate-adjusted associations</i>				
Men				
<i>Income</i>				
≤ 1000 (ref)	—	—	—	—
1000–3000	0.94 (0.50–1.75)	0.90 (0.27–3.01)	1.12 (0.49–2.54)	1.12 (0.54–2.32)
3001–6000	1.14 (0.64–2.04)	1.73 (0.61–4.89)	2.33*(1.14–4.79)	2.06*(1.06–4.02)
≥ 6000	1.93*(1.07–3.48)	3.96*(1.43–10.97)	4.37*(2.13–8.96)	5.58* (2.84–10.97)
Women				
<i>Income</i>				
≤ 1000 (ref)	—	—	—	—
1000–3000	0.96 (0.65–1.42)	0.75 (0.50–1.13)	0.92 (0.66–1.27)	1.03 (0.74–1.43)
3001–6000	1.61*(1.04–2.48)	1.83*(1.19–2.80)	1.66*(1.16–2.38)	1.05 (0.74–1.49)
≥ 6000	1.70***(0.97–2.98)	1.66***(0.95–2.92)	1.69*(1.06–2.71)	1.51***(0.96–2.38)

BMI = body mass index. * $P < 0.05$; ** $P < 0.10$. ^aMultivariate models were adjusted for age, marital status, smoking history and education level. Multinomial models were used for overweight/obesity; logistic models were used for large waist circumference and high waist-to-hip ratio.

with each individual index of obesity in both sexes (Table 3). After adjusting for other indices of obesity, measures of central fatness were more strongly associated with diabetes than more general measures of overweight and obesity. High WHR remained strongly and significantly associated with diabetes in both men and women; associations with large WC were also strong in women, although marginally

nonsignificant ($P < 0.10$). Models crossclassifying subjects based on central fatness and overweight also suggested that central fat was more strongly related to diabetes: overweight combined with high WHR was an especially strong predictor, but high WHR in the absence of overweight was also strongly associated with diabetes. Additionally, in women, there was a significant interaction between overweight and large WC (interaction $P = 0.06$); high WC without overweight was associated with substantially increased odds of diabetes, although associations were marginally nonsignificant.

Associations between prevalent hypertension and measures of obesity or central fatness were also strong and significant, albeit weaker than for diabetes (Table 3). After adjusting for other indices, associations remained significant for generalized overweight/obesity in men but for central fatness (high WHR) in women. However, associations with general obesity in women were similar in magnitude, albeit nonsignificant. As for diabetes, overweight combined with excessive central fatness was associated with especially high odds of prevalent hypertension in both sexes (Table 3). There was a significant interaction between overweight and high WHR in men (interaction $P = 0.12$). Measures of obesity were

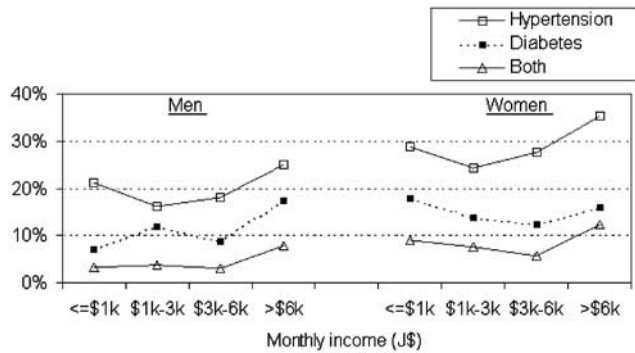


Figure 2 Age-adjusted prevalence of diabetes and hypertension by income.

Table 3 Associations between indices of obesity and cardiovascular risk factors

	Multivariate		Multivariate including other obesity measures	
	Diabetic	Hypertensive	Diabetic	Hypertensive
Men				
<i>Individual indices</i>				
Overweight/obese	2.74* (1.48–5.04)	3.05* (1.89–4.94)	1.44 (0.66–3.14)	2.27 (1.27–4.06)
Large WC	3.36* (1.81–6.27)	2.93* (1.74–4.91)	1.36 (0.55–3.28)	1.29 (0.63–2.65)
High WHR	4.52* (2.42–8.44)	2.69* (1.66–4.35)	2.97* (1.32–6.69)	1.55 (0.83–2.90)
<i>BMI+WHR</i>				
Overweight only	1.60 (0.68–3.79)	1.76‡ (0.93–3.37)	1.50 (0.62–3.64)	1.73 (0.89–3.36)
High WHR only	3.37* (1.07–10.57)	0.89 (0.35–2.32)	3.25* (1.03–10.23)	0.88 (0.34–2.30)
Overweight+high WHR	5.49* (2.63–11.43)	4.43* (2.49–7.88)	4.17* (1.44–12.09)	4.05* (1.73–9.42)
<i>BMI+WC</i>				
Overweight only	1.71 (0.77–3.79)	2.58* (1.41–4.71)	1.44 (0.63–3.26)	2.42* (1.31–4.47)
Overweight/large WC	3.98* (1.97–8.03)	3.98* (2.24–7.06)	1.94 (0.79–4.78)	3.02* (1.46–6.26)
Women				
<i>Individual indices</i>				
Overweight	2.36* (1.37–4.06)	1.49‡ (0.97–2.31)	1.37 (0.63–2.77)	0.98 (0.55–1.74)
Obese	3.34* (1.94–5.78)	2.90* (1.88–4.49)	1.68 (0.78–3.62)	1.68 (0.87–3.23)
Large WC	3.69* (2.27–5.99)	2.61* (1.80–3.77)	1.87‡ (0.91–3.86)	1.65 (0.90–3.02)
High WHR	3.32* (2.16–5.08)	1.94* (1.39–2.70)	2.45 (1.53–3.91)	1.50* (1.03–2.17)
<i>BMI+WHR</i>				
Overweight only	1.91‡ (0.88–4.12)	1.59‡ (0.99–2.71)	1.14 (0.44–2.92)	0.95 (0.49–1.83)
High WHR only	2.34‡ (0.99–5.54)	1.39 (0.74–2.63)	1.80 (0.73–4.48)	1.12 (0.58–2.18)
Overweight+high WHR	5.99* (3.01–11.93)	2.95* (1.85–4.73)	2.99* (1.13–7.92)	1.49 (0.73–3.04)
<i>BMI+WC</i>				
Overweight only	1.98 (0.81–4.89)	0.84 (0.41–1.72)	2.39‡ (0.95–5.97)	0.88 (0.43–1.80)
Overweight/large WC	4.50* (2.49–8.14)	2.54* (1.69–3.83)	3.28* (1.77–6.10)	2.21* (1.43–3.43)

Referent for all models = normal weight and/or central fatness. Numbers reflect sample sizes with income data. Multivariate models were adjusted for age, marital status, smoking history, education level and family history of diabetes (in diabetes models only) or hypertension (hypertension models only). Logistic models were used for individual indices and for overweight/obesity in women; multinomial models were used for other models, which had multilevel outcomes. WC = waist circumference; WHR = waist-to-hip ratio; BMI = body mass index. * $P < 0.05$. ‡ $P < 0.10$.

particularly strongly associated with having *both* hypertension and diabetes (4.7% of men, 8.4% of women). For example, overweight men with high WHR had a more than 10-fold increase in prevalence of both disorders, relative to normal weight men (adjusted multinomial OR 15.90, CI 5.18–48.75), and a six-fold higher prevalence of only one disorder (6.03, CI 3.21–11.29). Results were similar in women (OR 13.36, CI 4.26–41.84 for both disorders; 3.66 CI 2.27–5.90 for one disorder).

Obesity relationships with diabetes/hypertension stratified by poverty

We hypothesized that the lack of a strong income gradient in hypertension or diabetes—despite strong relationships between income and obesity—might be partly attributable to greater adverse effects of obesity among the poor. After stratifying on poverty level, data were too sparse to stratify using smaller income categories, or to account for multiple obesity indices. Nonetheless, there were no meaningful differences in relationship between obesity and hypertension among poor vs nonpoor adults (Figure 3a); interactions were not significant. Adjusted ORs for prevalent hypertension were similar among poor and nonpoor men for: overweight (3.03, CI 1.46–6.29; 3.18, CI 1.68–6.03); high WHR (2.86, CI 1.32–6.22; 2.97, CI 1.59–5.54) and large WC (2.55, CI 1.01–6.40; 3.27, CI 1.74–6.18). Likewise, ORs did not differ significantly in poor vs nonpoor women. ORs were 2.32 (CI 1.47–3.66) vs 1.91 (CI 1.09–3.72) with overweight; 1.61 (1.08–2.41) vs 2.54 (CI 1.46–4.41) with high WHR and 2.59 (CI 1.66–4.02) vs 3.27 (1.66–6.46) with large WC in poor vs nonpoor women, respectively.

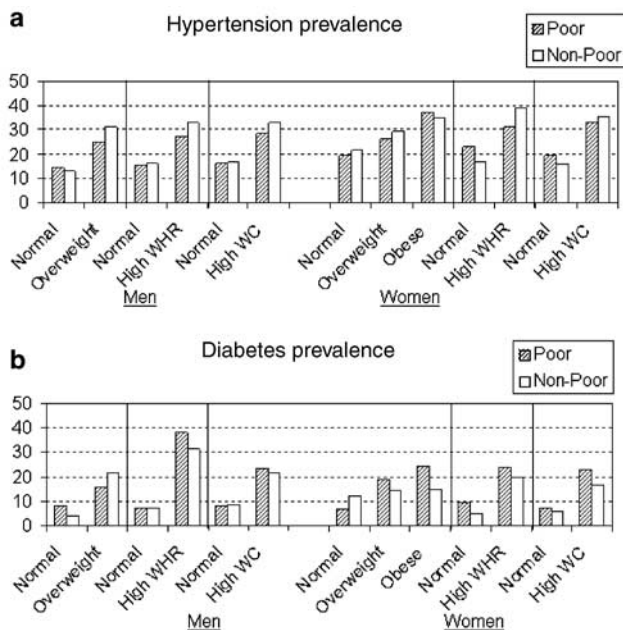


Figure 3 Age-adjusted prevalence of diabetes and hypertension by income and obesity.

Although the data suggested that associations between overweight/obesity and diabetes varied with poverty level, differences were not consistent in men and women (Figure 3b). In keeping with our hypothesis, obesity was more strongly associated with diabetes prevalence in poor (adjusted OR 4.89, CI 2.51–9.53) than in nonpoor women (adjusted OR 1.39, CI 0.50–3.91). There was a significant negative interaction between poverty and general obesity ($P < 0.05$). While interactions were not significant for other individual obesity indices, associations were somewhat stronger in poor women for large WC, but weaker for high WHR. Adjusted ORs for poor vs nonpoor women were 3.97 (CI 2.30–6.85) vs 3.16 (CI 1.08–9.23) for large WC, and 3.02 (CI 1.85–4.93) vs 5.12 (CI 1.94–13.50) for high WHR. In contrast, there was a significant positive interaction between poverty and overweight in men ($P < 0.05$). Overweight was not meaningfully associated with diabetes in poor men (adjusted OR 1.24 (0.49–3.14), despite a strong association in nonpoor men (OR 5.64, CI 2.14–14.88)). Again, interactions were not significant for other indices, but associations were somewhat weaker in poor than in nonpoor men for both high WHR (2.90, CI 1.09–7.71; and 5.73, CI 2.42–13.57) and large WC (2.27, CI 0.78–6.63; and 3.73, CI 1.66–8.36).

Discussion

In this periurban sample of adults from Jamaica, income was strongly and positively associated with prevalent overweight, obesity and central fatness in men. Men in the highest income group had four times higher odds of prevalent general obesity, and five to seven times higher odds of excessive central fatness than the poorest men. The magnitude of associations was weaker in women, but nonpoor women remained nearly twice as likely to be obese than poor women. Particularly in men, high income was also more strongly related to prevalence of overweight combined with central fat than to overweight or obesity alone. Only 7.6% of poor men had combined overweight and high WHR, vs 23.0% of nonpoor men. In women, this pattern of obesity was only slightly less prevalent among the poor (34.0%) than the nonpoor (40.5%).

The weaker associations in women may be attributable at least in part to high levels of obesity observed among even the poorest women. Levels of general obesity and central fatness in poor women ranged from 30 to 56%. In contrast, levels of obesity and central fatness in the poorest men were low, ranging from 4 to 10% percent. Recent studies in several other middle-income countries have also reported fairly high levels of obesity among poor women.^{6,7,12,26} Several of these studies reported similar sex disparities in the strength of the relationship between income and obesity.^{5,12} Like our data, these studies observed that in high-SES groups, obesity levels in women appeared to reach thresholds or even to decline. Thus in addition to rising levels among poor women, some researchers have suggested that weak associations between income and obesity may be in part a result of growing

awareness of health and nutrition issues, as well as changing perceptions of weight control and attractiveness, which may influence diet and exercise patterns in high-SES groups.¹² If so, these trends may be initial markers of a transition from the positive SES-obesity association typical of developing countries, to the inverse association typical in more Westernized, industrialized nations.^{34,35} Growing obesity and central fatness among the poor may be a result not only of increasing adoption of more 'Western' lifestyles, but also of elevated risk of selective abdominal adiposity associated with undernutrition in early life.^{36–38} To develop effective prevention programs, more research is needed to determine how obesogenic diet and activity patterns may be evolving across different levels of SES in middle-income developing countries, and to assess whether other factors may explain increasing obesity in economically disadvantaged groups.

The rising obesity—and particularly central fatness—in low-income groups is problematic given the strong association of obesity with both diabetes and hypertension. Overall, prevalence of each disorder was high (25% for hypertension, 14% for diabetes), and comparable to rates in developed countries.^{39–41} Overweight combined with high WHR was an especially strong predictor of prevalent hypertension and diabetes. In addition, high WHR was strongly associated with increased odds of prevalent diabetes, independent of high BMI and large WC. Stronger associations with WHR than with WC or BMI for insulin-related disorders have been observed in other studies; it has been speculated that this may be attributable to the fact that WHR reflects variation in muscle mass—of importance for systemic insulin sensitivity—as well as visceral fat.⁴²

Despite finding strong positive relationships between income and all measures of obesity, associations between income and both of these obesity-related metabolic disorders were weak and nonlinear. The strong positive associations between income and obesity were incongruous with the weak, nonlinear associations between income and these disorders. Indeed, contrary to expectations based on obesity levels, among women, prevalence of diabetes was somewhat higher among the poor than the nonpoor. Thus explicit research on factors other than obesity that may contribute to metabolic disorders such as hypertension and diabetes is needed to fully assess how the changes in lifestyles and the social environment may contribute to CVD risk in populations undergoing epidemiologic and nutrition transitions. Data from the Dutch Famine suggest that adult obesity may exacerbate adverse effects of prenatal undernutrition on diabetes and impaired glucose tolerance, suggesting that the poor may have excessive levels of these disorders in part as a consequence of obesity.⁴³ However, the incongruity in the income distributions of obesity vs CVD risk did not seem to be explained by disproportionately high odds of these disorders associated with obesity among the poor. Stronger relationships between obesity and diabetes were found only in women, but not in men. Unfortunately, our data do not include measures of numerous other factors—such as low

physical activity or early undernutrition—which may also contribute to the high prevalence of metabolic disorders in the poor. Other studies suggest that higher levels of physical activity may help to reduce the risk of diabetes among overweight low-income men.^{44–46} It has also been suggested that undernutrition in early life may also contribute to risk of diabetes and/or hypertension, especially in low-income groups, even in the absence of obesity.^{36,47–49} Future research using other data is needed to explore these issues.

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