Association of socioeconomic factors with body mass index, obesity, physical activity, and dietary factors in Belo Horizonte, Minas Gerais State, Brazil: *The BH Health Study*

Associação de fatores socioeconômicos com o índice de massa corporal, obesidade, atividade física e dieta em Belo Horizonte, Minas Gerais, Brasil: *Estudo Saúde em Beagá*

Asociación de factores socioeconómicos con el índice de masa corporal, obesidad, actividad física, y dieta en Belo Horizonte, Minas Gerais, Brasil: *Estudio Salud en Beagá*

Julia Ward [1,2]
Amélia Augusta de Lima Friche [3,4]
Waleska Teixeira Caiaffa [3,4]
Fernando Augusto Proietti [5,6]
César Coelho Xavier [3,6]
Ana V. Diez Roux [7]

[1] *School of Public Health, University of Michigan, Ann Harbor, U.S.A.*
[2] *University of North Carolina, Gillings School of Global Public Health, Chapel Hill, U.S.A.*
[3] *Observatório de Saúde Urbana de Belo Horizonte, Universidade Federal de Minas Gerais, Belo Horizonte, Brasil.*
[4] *Faculdade de Medicina, Universidade Federal de Minas Gerais, Belo Horizonte, Brasil.*
[5] *Centro de Pesquisas René Rachou, Fundação Oswaldo Cruz, Belo Horizonte, Brasil.*
[6] *Faculdade de Saúde e Ecologia Humana, Vespasiano, Brasil.*
[7] *School of Public Health, Drexel University Philadelphia, U.S.A.*

Correspondence
J. Ward
Gillings School of Global Public Health, University of North Carolina.
135 Dauer Drive, Chapel Hill, NC 27599, USA.
jbward@umich.edu

Abstract

Obesity prevalence is rapidly increasing in developing countries. Existing research investigating social patterning of obesity and its risk factors in Latin American urban contexts has inconsistent findings. This study analyzed a multistage household survey in adults in Belo Horizonte, Minas Gerais State, Brazil. Marginal models were used to examine the association of education and household and neighborhood income with body mass index (BMI), obesity, physical inactivity, and low fruit and vegetable intake after adjusting for age and ethnicity and stratifying by sex. BMI and obesity were inversely associated with education in women. BMI was positively associated with household and neighborhood income in men. Additionally, physical inactivity and low fruit and vegetable intake were inversely associated with education and household income in both men and women, and physical inactivity was inversely associated with neighborhood income in men. Understanding the drivers of these patterns will allow for development of appropriate policy and interventions to reduce cardiovascular disease risk in large cities in Latin America.

Socioeconomic Factors; Body Mass Index; Obesity; Urban Health

Resumo

A prevalência da obesidade está aumentando nos países em desenvolvimento. Estudos investigando os padrões sociais da obesidade e seus fatores de risco em áreas urbanas da América Latina têm resultados inconsistentes. Neste estudo foram analisadas as informações provenientes de inquérito populacional sobre a saúde de adultos residentes em Belo Horizonte, Minas Gerais, Brasil. Foram utilizados modelos marginais para examinar a associação entre a escolaridade, a renda familiar e da vizinhança com o IMC (índice de massa corporal), a obesidade, a atividade física e o consumo de frutas e verduras. O IMC e a obesidade se associaram inversamente à escolaridade entre as mulheres e o IMC positivamente à renda do domicilio e da vizinhança entre os homens. O baixo consumo de frutas e verduras e a inatividade física foram inversamente associados à escolaridade e à renda familiar em ambos os sexos. A inatividade física se associou inversamente à renda da vizinhança entre os homens. Compreender as causas da distribuição social da obesidade é importante para reduzir o risco de doença cardiovascular nos centros urbanos da América Latina.

Fatores Socioeconômicos; Índice de Massa Corporal; Obesidade; Saúde Urbana

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Introduction

In many countries a nutrition and physical activity transition has accompanied the epidemiologic shift from infectious to chronic disease [1,2]. Recognition of the influence of obesity on non-communicable disease rates has led to an increasing focus on prevalence of obesity and its risk factors worldwide. Obesity, defined as a body mass index (BMI) ≥ 30kg/m², is a physical activity and nutrition-related risk factor for many chronic diseases including hypertension, diabetes, cardiovascular disease, and several types of cancer [3].

The association of obesity with socioeconomic factors has been well documented in developed countries [4] where cardiovascular disease risk factors such as obesity are inversely associated with socioeconomic position [4,5,6]. Health behaviors such as diet and physical activity may represent possible mediators in the association of socioeconomic position with obesity and have shown inverse trends with socioeconomic position similar to those with obesity in developed nations [4]. Additionally, studies in industrialized nations have demonstrated that neighborhood factors, such as availability of healthy foods and recreational resources, influence diet and physical activity over and above individual-level characteristics [7].

Research demonstrates that rates of chronic diseases and associated risk factors are increasing faster in developing regions than in developed regions and that cardiovascular disease is the greatest cause of mortality in developing nations [8]. The largest increase in BMI between 1980 and 2008 occurred in areas of Oceania and Latin America [8]. In Brazil, for example, between 1975 and 2008 the percentage of the population that classified as obese increased from 2.7 to 16.0 in men and from 7.4 to 21.4 in women [9,10].

Historically in developing nations, low socioeconomic position was protective against cardiovascular disease risk factors [9,11]. However, a growing body of research in Latin America indicates a shift in the burden of these risk factors to impoverished populations [12,13,14]. Additionally, urban populations have been shown to have a higher prevalence of obesity, low levels of physical activity, and poor diet [14,15]. Given the already high and growing levels of urbanization in many low- and middle-income countries, describing the association of these risk factors with socioeconomic position in urban settings is of special significance. Describing and understanding the association of obesity and associated behavioural risk factors with socioeconomic position in countries such as Brazil, a nation with large urban centers that suffers from great inequity, is fundamental to developing appropriate policies and interventions to stymie the obesity epidemic.

In Brazil in 1989, obesity in adults was positively associated with socioeconomic position [16]. In 2003, obesity prevalence remained higher in high-income groups than in low-income groups, but the rate of increase was higher in low-income communities [9]. It is important to continue to characterize the magnitude and direction of the association of obesity, and the associated behaviors of physical inactivity and poor diet, with socioeconomic position as it shifts over time to burden impoverished populations. Utilizing both individual- and contextual-level measures of socioeconomic position can provide greater insight into the specific aspects of socioeconomic position that influence health. The purpose of this study is to investigate the association of both individual-level and neighborhood-level measures of socioeconomic position on risk factors for cardiovascular disease in an urban Brazilian population. Using a unique household survey, we examine the influence of education, household income, and neighborhood income on BMI, obesity, physical activity, and dietary factors in the city of Belo Horizonte, Minas Gerais State, Brazil. Given the shifting trends observed in Brazil over the last several decades, we expect that the present pattern of these outcomes in Belo Horizonte will mirror that of developed nations.

Methods

Study population

From August 2008 to February 2009 the Belo Horizonte Observatory for Urban Health conducted a cross-sectional survey in Belo Horizonte. The survey was conducted in the Barreiro and West districts, two of the city's nine districts. Each district has approximately 250,000 inhabitants, and the two districts have a total geographical area of 33.16km². The West and Barreiro districts were chosen due to their geographical proximity and their significant internal heterogeneity of various demographic, socioeconomic, and health indicators. These characteristics were similar to those of other city districts.

Details of the study design have been reported previously [17]. In brief, stratified three-stage cluster sampling was used to select the sample; this included selection of census tracts as the first stage, households as the second stage, and individuals as the third stage. The sample strata were defined according to the Health Vulnerability Index [18], an index created by combining social, demographic, economic and health indicators from the census for each census tract. Census tracts, defined by the Brazilian Census Bureau, include an average of 1,000 residents. In the first stage of sampling, 149 census tracts were randomly selected from a total of 588 tracts in the sampling frame. A total of 6,493 households made up the 149 tracts. In the second stage of sampling, vacant lots, institutional and commercial buildings, and households that could not be reached after three attempts were deleted. In the final sampling stage, one adult from each household was selected to participate; interviewers randomly selected this participant from a list of resident adults for each selected household. Approximately 75% of the households agreed to participate leaving a total study sample of 4,048 households. The main causes of refusal were inability to contact the selected participant after three consecutive attempts and participants refusing to answer the questionnaire due to its length. Those who refused to participate did not differ from participants who completed the questionnaire by sex or age.

Before the survey was conducted, the instruments were pilot tested, and the 23 interviewers completed centralized training. Interviewers visited each sample household, and if the selected resident was present at the time, the interviewer explained the study aims and procedures and answered participant questions. Participants agreeing to take part in the study signed Informed Consent Forms. The interviewer then administered the face-to-face questionnaire, which lasted approximately 45 minutes, and performed anthropometric measurements.

We originally intended to interview all adults in the household to increase sample size after estimating a total sample size of approximately 3,000 persons over the age of 18 from 1,750 households. These calculations were based on the 2000 Brazilian Census and an 80% response rate [19]. Assuming three persons per household and an average within household correlation in outcomes of 0.5, we would have had 80% power to detect differences as small as 0.2 standard deviations in the outcome when comparing two groups of 208 persons. However, we underestimated the number of eligible households; we ended up with a study sample of 4,048 households and only needed to sample one adult from each. Thus, power was even greater than expected due to the larger sample size and lack of clustering within household.

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Data sources

Participants responded to a questionnaire made up of six modules: household information, sociodemographic data, health, habits and behaviors, anthropometric evaluation, and social determinants of health. Participants who did not report education (n = 4) or household income (n = 98), had no information on neighborhood income (n = 17), or who had missing BMI (n = 11) were excluded, leaving a total study sample of 3,918 participants. An additional 226 participants did not report physical activity and were excluded from the physical activity analyses.

The main outcomes of interest were BMI, obesity, low physical activity, and low fruit and vegetable intake. BMI was calculated as weight in kg/(height in m^2). Interviewers used a standard scale (brand TANITA BF 542, Tanita Corp., USA) and stadiometer to measure height and weight. Interviewers were trained to correctly perform measurements following standard protocols. Obesity was defined as BMI $\geq 30kg/m^2$ based on WHO recommendations.

Participants responded to questions regarding the frequency and duration of physical activity from the Portuguese version of the *International Physical Activity Questionnaire* (IPAQ), version 8. This instrument is recommended for national prevalence studies [20]. The physical activity score utilized for analysis was calculated as the sum of minutes of moderate activity, plus twice the minutes of vigorous activity. Noncompliance with physical activity guidelines was defined as a score below 150 minutes/week as currently recommended by the U.S. Surgeon General's Report, American College of Sports Medicine, and Centers for Disease Control and Prevention [21,22,23].

Diet was assessed using items adapted from other international and Brazilian surveys [24]. Consumption of less than three fruits and vegetables per day has been associated with increased risk of cardiovascular events [25], and we wished to explore the association of socioeconomic position with very low fruit and vegetable consumption. Thus, for our analyses, subjects who consumed fruits or vegetables less than three days per week were considered to have low levels of healthy food consumption. Fruit and vegetable intake was selected for its simplicity and because it has been shown to be a useful marker of dietary quality and related to social and economic factors in prior work [26].

The exposures of interest were years of education, household income, and neighborhood income. Education is a consistent predictor of population health, especially in developing contexts [27]. Household income reflects material conditions that impact health [27], and neighborhood income was utilized because contextual socioeconomic position measures have been shown to influence health after accounting for individual factors [7]. Education was classified into three categories: 0-8 years, 9-11 years, and 12+ years. Gross monthly household income was classified into three categories in terms of the minimum Brazilian wage (about US$ 290.00): < 2 minimum wages (< US$580), 2-5 minimum wages (US$580-1,450), and >5 minimum wages (> US$1,450). This categorization was based on the income distribution of participants in this study, previous studies, and the Brazilian Institute of Geography and Statistics (IBGE) 2010 census report [28,29]. The neighborhood indicator examined was monthly income per capita obtained from the 2000 and 2010 Brazilian census [19,29]. We categorized this variable into tertiles. Census tracts were used as proxies for neighborhoods.

Data analysis

The distribution of BMI, obesity, physical activity, and dietary intake by income and education level was first summarized with descriptive and graphical analyses. Spearman correlations between income and education level were calculated. Multivariable linear and logistic regression models were run to examine the association between the outcomes of BMI, obesity, physical activity, and diet with education level, household income, and neighborhood income. We tested for effect modification by sex through stratified analyses and by including interaction terms in the regression models. The associations of BMI with education, household income, and neighborhood income differed significantly by sex (P for interaction terms introduced separately: < 0.0001 for sex and education, < 0.0001 for sex and income, and < 0.0001 for sex and neighborhood), thus, results are stratified by sex. The interaction terms between sex and education, household income, and neighborhood income for the physical activity and diet outcomes were not statistically significant; however, results are shown stratified by sex to facilitate comparison with BMI analyses.

All models were adjusted for age and ethnicity because we conceptualized these variables as possible confounders in the association between socioeconomic position and the outcomes of interest. In order to observe the associations of each socioeconomic position measure with the outcomes independent of the other two socioeconomic position measures, the final models were mutually adjusted for education, household income, and neighborhood income by adding these variables to the unadjusted model. Additionally, we ran intermediate models including only education and household income, but these results were very similar to the final models and were therefore not reported in the tables. Marginal models were used to account for clustering within census tracts [30]. We hypothesized that the socioeconomic position measures would be inversely associated with BMI, obesity, lack of compliance with physical activity guidelines, and low fruit and vegetable consumption.

Results

After excluding participants who were missing covariate data, the total sample size was 2,317 women and 1,601 men. The 130 excluded participants were similar in socioeconomic position and risk factor characteristics to those included in the analyses. Table 1 displays selected individual characteristics of the sample, stratified by sex. Men made up 40.8% of the sample and had an average age of 43.5 years, younger than women whose average age was 44.9 years. The ethnic composition of the sample was similar for men and women with the majority identifying as mixed ethnicity or white. Men reported more years of education than women with 18.4% of men reporting 12+ years of education compared to 16.4% of women. Women reported lower household income than men with 31.6% of women in the lowest income category compared to 19.5% of men. However, men and women had similar average neighborhood income. The average BMI of women was 26.5kg/m^2 compared to 25.5kg/m^2 in men, and 22.8% of women were classified as obese compared to 14.9% of men. Men were more likely to eat fruits or vegetables less than 3 days/week than women (40.5% vs. 31.2%, respectively), however, women were more likely to complete fewer than 150 minutes of physical activity per week than men (77.8% vs. 67.4%, respectively).

Table 2 shows the mean differences in BMI by education, household income, and neighborhood income. Introduction of interaction terms into the model indicated that associations of BMI with education, household income, and neighborhood income differed significantly by sex.

Table 1

Selected characteristics of a sample from the Barreiro and West Districts of Belo Horizonte, Minas Gerais State, Brazil, 2008-2009.

Variable	Total (N = 3,918)	Men (n = 1,601)	Women (n = 2,317)	p-value *
Male (%)	40.8			
Married (%)	42.9	48.5	39.1	< 0.0001
Age in years, Mean ± SD [range]	44.3±16.9 (18.0-95.0)	43.5±17.1 (18.0-91.0)	44.9±16.8 (18.0-95.0)	0.0088
Ethnicity (%)				
White	38.2	36.0	39.7	
Black	12.9	14.5	11.7	
Mixed ("parda")	47.7	48.7	47.0	
Other	1.3	0.9	1.6	0.0047
Education (%) [years]				
0-8	47.7	45.4	49.3	
9-11	35.1	36.2	34.3	
12+ years	17.2	18.4	16.4	0.0421
Household monthly income, in minimum wages (%)				
Low (< 2)	26.7	19.5	31.6	
Medium (2-5)	45.8	47.9	44.4	
High (> 5)	27.5	32.6	24.0	< 0.0001
Nominal monthly income per person (BRL), [Mean ± SD (Range)]	870.1±771.7 (181.8-4847.8)	863±781.0 (181.8-4847.8)	874.4±765.3 (181.8-4847.8)	0.6761
BMI (kg/m^2), Mean ± SD [range]	26.1±5.1 (13.9-53.0)	25.5±4.5 (14.0-46.7)	26.5±5.5 (13.9-53.0)	< 0.0001
Obesity (%) [BMI ≥ 30]	19.6	14.9	22.8	< 0.0001
Eat fruits or vegetables < 3 days/week (%)	35.0	40.5	31.2	< 0.0001
Physical inactivity, < 150min/week (%)	73.57	67.4	77.8	< 0.0001

BMI: body mass index; SD: standard deviation.

* Chi-square tests for categorical variables and t-tests for continuous variables were performed to determine differences between men and women.

Table 2

Crude and adjusted mean differences (95%CI) in BMI according to socioeconomic characteristics stratified by sex of a sample from the Barreiro and West Districts of Belo Horizonte, Minas Gerais State, Brazil, 2008-2009.

Individual socioeconomic variables	Men (n = 1,601)		Women (n = 2,317)	
	Model 1	Model 2	Model 1	Model 2
Education				
Low	-0.94 (-1.53; -0.35)	-0.03 (-0.71; 0.65)	1.59 (0.93; 2.25)	1.79 (1.03; 2.55)
Medium	-0.32 (-0.93; 0.30)	0.17 (-0.48; 0.85)	0.92 (0.30; 1.54)	1.03 (0.37; 1.70)
High	0.00	0.00	0.00	0.00
p-value for trend	0.0025	0.6653	< 0.0001	< 0.0001
Monthly income (minimum salary)				
Low	-1.63 (-2.25; -1.01)	-1.26 (-1.93; -0.58)	0.23 (-0.38; 0.85)	-0.61 (-1.29; 0.07)
Medium	-0.69 (-1.22; -0.17)	-0.46 (-1.05; 0.14)	0.39 (-0.09; 0.87)	-0.19 (-0.71; 0.32)
High	0.00	0.00	0.00	0.00
p-value for trend	< 0.0001	0.0013	0.2865	0.1992
Neighborhood measure (percentile of nominal monthly income per person)				
1st tertile (low)	-1.18 (-1.68; -0.67)	-0.76 (-1.28; -0.23)	0.57 (-0.04; 1.17)	0.22 (-0.40; 0.84)
2nd tertile	-0.34 (-0.81; 0.13)	-0.15 (-0.63; 0.34)	0.07 (-0.44; 0.59)	-0.13 (-0.66; 0.41)
3rd tertile (high)	0.00	0.00	0.00	0.00
p-value for trend	< 0.0001	0.0145	0.1606	0.5345

95%CI: 95% confidence interval; BMI: body mass index.

Model 1: adjusted for age and ethnicity; Model 2: adjusted for age, ethnicity, education, income, and neighborhood.

Thus, results are stratified by sex. In the crude analysis for women, average BMI had an inverse association with education, a positive association with household income, and showed no clear trend with neighborhood income. After adjusting for age, ethnicity, education, and neighborhood, only the BMI and education association remained significant. After adjustment, the mean BMI of women with 0-8 years of education was 1.79 (95% confidence interval – 95%CI: 1.03-2.55) kg/m^2 higher than that of women with 12+ years of education. For men, average BMI had significant positive associations with income and neighborhood and showed no clear trend with education. After adjustment for all covariates, the mean BMI of low-income men was 1.26 (95%CI: 0.58-1.93) kg/m^2 lower than that of high-income men, and the mean BMI of men in the poorest neighborhoods was 0.76 (95% CI: 0.23-1.28) kg/m^2 lower than that of men in the wealthiest neighborhoods.

The social patterning of the odds of obesity showed similar trends to those shown with BMI in women only (Table 3). After adjusting for household and neighborhood income, the odds of obesity in women with 0-8 years of education were 2.03 (95% CI: 1.36-3.03) times the odds in women with 12+ years of education. In men, however, when BMI was dichotomized into obese and not obese, we no longer observed trends with any socioeconomic position measure after adjusting for all covariates. Low income did appear to have a slight protective effect for men, but this trend was non-significant. No significant associations were found between obesity and neighborhood income for either men or women.

Table 4 displays the odds ratios (OR) of less than 150 minutes/week of physical activity by education, household income, and neighborhood income, stratified by sex. Results are shown stratified by sex to facilitate comparison with BMI analyses. For women, less than 150 minutes/week of physical activity had a significant inverse association with income and education levels. After adjusting for covariates, the odds of less than 150 minutes/week of physical activity in women with 0-8 years of education were 2.12 (95%CI: 1.49-3.02) times the odds in women with 12+ years of education, and the odds of less than 150 minutes/week of physical activity in low-income women were 2.08 (95%CI: 1.47-2.96) times the odds in high-income women. A similar, albeit weaker, pattern was seen in men with regards to education. However, the income trend was not significant in men. Additionally, for men, less than 150 minutes/week of physical activity had

Table 3

Crude and adjusted OR (95%CI) of obesity according to socioeconomic characteristics stratified by sex of a sample from the Barreiro and West Districts of Belo Horizonte, Minas Gerais State, Brazil, 2008-2009.

Individual socioeconomic variables	Men (n = 1,601)		Women (n = 2,317)	
	Model 1	Model 2	Model 1	Model 2
Education				
Low	1.05 (0.71; 1.57)	1.40 (0.88; 2.22)	1.90 (1.35; 2.67)	2.03 (1.36; 3.03)
Medium	1.28 (0.83; 1.97)	1.45 (0.92; 2.29)	1.53 (1.09; 2.16)	1.60 (1.11; 2.31)
High	1.00	1.00	1.00	1.00
p-value for trend	0.3803	0.2630	0.0011	0.0024
Monthly income (minimum salary)				
Low	0.65 (0.43; 0.98)	0.65 (0.41; 1.04)	1.14 (0.85; 1.53)	0.86 (0.62; 1.20)
Medium	0.90 (0.65; 1.24)	0.87 (0.60; 1.24)	1.12 (0.89; 1.42)	0.91 (0.70; 1.19)
High	1.00	1.00	1.00	1.00
p-value for trend	0.1142	0.1984	0.5949	0.6698
Neighborhood measure (percentile of nominal monthly income per person)				
1st tertile (low)	0.76 (0.53; 1.09)	0.78 (0.53; 1.15)	1.20 (0.90; 1.59)	1.03 (0.77; 1.38)
2nd tertile	1.12 (0.85; 1.49)	1.11 (0.82; 1.48)	1.02 (0.77; 1.35)	0.93 (0.70; 1.24)
3rd tertile (high)	1.00	1.00	1.00	1.00
p-value for trend	0.0445	0.0812	0.3420	0.7238

95%CI: 95% confidence interval; OR: odds ratio.

Model 1: adjusted for age and ethnicity; Model 2: adjusted for age, ethnicity, education, income, and neighborhood.

Table 4

Crude and adjusted OR (95%CI) of less than 150 minutes/week of physical activity according to socioeconomic characteristics stratified by sex of a sample from the Barreiro and West Districts of Belo Horizonte, Minas Gerais State, Brazil, 2008-2009.

Individual socioeconomic variables	Men (n = 1,505)		Women (n = 2,188)	
	Model 1	Model 2	Model 1	Model 2
Education				
Low	2.47 (1.73; 3.53)	1.55 (1.07; 2.26)	3.38 (2.48; 4.60)	2.12 (1.49; 3.02)
Medium	1.69 (1.24; 2.31)	1.24 (0.89; 1.73)	2.09 (1.56; 2.81)	1.61 (1.19; 2.18)
High	1.00	1.00	1.00	1.00
p-value for trend	< 0.0001	0.0683	< 0.0001	0.0002
Monthly income (minimum salary)				
Low	1.97 (1.41; 2.76)	1.33 (0.93; 1.90)	3.15 (2.32; 4.28)	2.08 (1.47; 2.96)
Medium	1.94 (1.45; 2.61)	1.46 (1.08; 1.99)	2.14 (1.64; 2.80)	1.63 (1.23; 2.18)
High	1.00	1.00	1.00	1.00
p-value for trend	< 0.0001	0.0529	< 0.0001	0.0001
Neighborhood measure (percentile of nominal monthly income per person)				
1st tertile (Low)	2.80 (1.95; 4.03)	2.04 (1.41; 2.96)	2.23 (1.66; 3.01)	1.31 (0.96; 1.80)
2nd tertile	1.92 (1.40; 2.63)	1.56 (1.15; 2.13)	1.31 (0.99; 1.73)	0.97 (0.74; 1.28)
3rd tertile (High)	1.00	1.00	1.00	1.00
p-value for trend	< 0.0001	0.0006	< 0.0001	0.1200

95%CI: 95% confidence interval; OR: odds ratio.

Model 1: adjusted for age and ethnicity; Model 2: adjusted for age, ethnicity, education, income, and neighborhood.

a significant inverse association with neighborhood income. After adjusting for other covariates, the odds of less than 150 minutes/week of physical activity in men in the poorest neighborhoods were 2.04 (95%CI: 1.41-2.96) times the odds in men in the wealthiest neighborhoods. Less consistent neighborhood patterns were observed in women.

Table 5 displays the crude and covariate adjusted OR of consuming fruits or vegetables less than three days/week by education, household income, and neighborhood income, stratified by sex. For women, low consumption of fruits and vegetables had significant inverse associations with education and household income. After adjusting for covariates, the odds of consuming fruits or vegetables less than three days/week in women with 0-8 years of education were 1.61 (95%CI: 1.15-2.26) times the odds in women with 12+ years of education, and the odds of consuming fruits or vegetables less than three days/week in low-income women were 2.21 (95%CI: 1.65-2.96) times the odds in high-income women. Similar but weaker trends were found in men for both education and household income. However, the overall trend in fruit and vegetable consumption across categories of education in men was not significant (p-value = 0.0777). No association was found between fruit and vegetable consumption and neighborhood income in either men or women after adjusting for covariates.

Discussion

In developed countries, chronic disease risk factors such as obesity, physical inactivity, and inadequate fruit and vegetable intake have long been associated with low socioeconomic position [4,5,6]. The social gradient in developing countries has been less consistent, and most studies in these contexts have investigated BMI and obesity exclusively [9,11,12,13,14]. Studies in Brazil over the past several decades suggest a shifting social gradient as the country progresses through the nutrition transition. In 1989, a positive association between income and obesity was found in both Brazilian men and women [16]. 14 years later, a nationally representative sample of Brazilian adults showed that high-income groups still had higher obesity prevalence than low-income groups, but low-income groups had a higher rate of increase [9]. This shifting pattern is not unique to Brazil. A review of low-income countries found a higher prevalence of overweight in high-ed-

Table 5

Crude and adjusted OR (95%CI) of consuming fruits or vegetables less than three days per week according to socioeconomic characteristics stratified by sex of a sample from the Barreiro and West Districts of Belo Horizonte, Minas Gerais State, Brazil, 2008-2009.

Individual socioeconomic variables	Men (n = 1,601)		Women (n = 2,317)	
	Model 1	Model 2	Model 1	Model 2
Education				
Low	1.99 (1.46; 2.71)	1.47 (1.02; 2.13)	2.47 (1.85; 3.30)	1.61 (1.15; 2.26)
Medium	1.35 (1.00; 1.83)	1.15 (0.82; 1.60)	1.43 (1.04; 1.97)	1.09 (0.79; 1.51)
High	1.00	1.00	1.00	1.00
p-value for trend	< 0.0001	0.0777	< 0.0001	0.0021
Monthly income (minimum salary)				
Low	2.23 (1.68; 2.94)	1.76 (1.26; 2.44)	2.85 (2.19; 3.70)	2.21 (1.65; 2.96)
Medium	1.37 (1.07; 1.74)	1.16 (0.89; 1.51)	1.65 (1.27; 2.14)	1.39 (1.05; 1.85)
High	1.00	1.00	1.00	1.00
p-value for trend	< 0.0001	0.0021	< 0.0001	< 0.0001
Neighborhood measure (percentile of nominal monthly income per person)				
1st tertile (low)	1.62 (1.23; 2.14)	1.20 (0.87; 1.64)	1.65 (1.29; 2.10)	1.08 (0.84; 1.40)
2nd tertile	1.30 (0.96; 1.76)	1.11 (0.81; 1.52)	1.51 (1.20; 1.91)	1.24 (0.99; 1.54)
3rd tertile (high)	1.00	1.00	1.00	1.00
p-value for trend	0.0026	0.5229	0.0002	0.1442

95%CI: 95% confidence interval; OR: odds ratio.

Model 1: adjusted for age and ethnicity; Model 2: adjusted for age, ethnicity, education, income, and neighborhood.

ucation groups in 35 of 39 countries; however, the rate of increase in overweight prevalence was higher in the low-education groups in 21 countries [31]. Our study demonstrates a next step in the shift reported by previous studies in Brazil.

The social patterning of obesity greatly depends on the region of Brazil examined. In 1996 in the less developed northeastern region of Brazil, obesity in men was positively associated with income but not with education, and obesity in women was positively associated with income and inversely with education [31]. In the more developed southeastern region, the same study found a positive association between obesity and income in men and a clear inverse relationship between obesity and education in women [32]. Our study was carried out in a developed Brazilian city and was consistent with the findings in the more developed southeastern region; the women with the lowest education in our sample had the highest average BMI and obesity prevalence.

Obesity was once a disease of the elite, but as a country's GNP (Gross National Products) increases, the social gradient reverses. For women, the crossover takes place earlier than for men, when a country reaches a GNP per capita of approximately US$2,500 [33]. Our findings of an inverse association of female BMI and obesity with education and a positive association between male BMI and income are consistent with other studies in Latin America that report similar gender differences in social patterning [14,34]. Throughout Latin America, low socioeconomic position continues to protect against obesity in men while increasing the risk of obesity in women.

The opposite social patterning of BMI and obesity in men and women could be partly influenced by differing ideal body images for men and women. Women often find smaller body sizes more attractive while men are generally dissatisfied with small bodies [35], and well-educated women at any given BMI are more sensitive to this image [36]. The directionality difference in men and women could also be due to body image and selection factors, such as heavier individuals experiencing discrimination when pursuing higher paid jobs, playing a more important role in women than in men. The strong association of BMI and obesity with education in women could be due to increased exposure among well-educated women to media that promote thin body shapes; well-educated women may also have a stronger desire to take up less physical space in a patriarchal society [36]. The weaker associations observed for income than for education in women may be due to the fact that women in every education level made less money than men. Consequently, income may not accurately capture a woman's social position.

In developed countries, prevalence of physical inactivity is higher in low socioeconomic position groups [21,23], and a similar pattern has begun to emerge in developing countries [37]. Nevertheless, our study is the first in Brazil to find a social gradient of physical inactivity similar to that of developed countries. Studies in other regions of Brazil and Latin America found either a positive association [22,38] or no association [14,22] between socioeconomic position and physical inactivity. Our findings of strong income and education patterning of physical activity, especially in women, demonstrate the shifting patterns in physical activity practices in urban regions of Brazil where the elite may have resources permitting higher levels of activity, especially for leisure [39].

Education and income had independent effects on physical activity in women and to an extent in men in Belo Horizonte. Those with less education may lack the health-knowledge and social capital to sustain healthy physical activity levels, and those with lower income tend to have less leisure time and opportunity for recreational activities [11,40]. Additionally, low-education and low-income populations have less financial and social resources to avoid the environments that promote physical inactivity [41].

In developed countries, fruit and vegetable consumption is associated with higher levels of education [42], and similar patterns are beginning to appear in developing nations [43,44,45]. Our results of low fruit and vegetable consumption in low-income and low-education groups of men and women were consistent with other findings in Brazil [46,47]. In recent years, sugary and processed foods have become more available in Brazil [48], and healthy foods, such as fruits and vegetables, are more costly than low-quality calorie dense foods [49]. High-income populations have greater purchasing power for more expensive healthy foods, while low-income populations are more constrained in their choices [41]. The additional independent inverse effect of education on fruit and vegetable consumption indicates that education captures aspects of socioeconomic position that affect access to fruits and vegetables that income alone does not.

In men we found an inverse association between physical inactivity and poor diet and socioeconomic position, a seemingly contradictory positive association between BMI and socioeconomic position, and no association between obesity and socioeconomic position. Although the behavioral risk factors for obesity have begun to change in both men and women in Brazil, it is possible that the effects on social patterning of BMI have not yet become apparent in men. Additionally, the significant positive association in men of income with BMI but not with obesity is plausible because BMI as a continuous measure is more sensitive to differences that the dichotomized obesity variable could not detect. While our study suggests that men with higher incomes may have higher BMI, our findings also indicate that higher income men have the resources to consume healthy diets and participate in physical activity to prevent obesity. If the pattern of physical inactivity and poor diet in men of low socioeconomic position persists, we may observe an eventual shift in the BMI and obesity trends in men in Brazil.

Area-level income was not a consistent predictor of health outcomes in this study. Neighborhood income was not associated with any of the three outcomes in women; however, there was evidence of a positive association with BMI and an inverse association with physical activity in men. Studies of neighborhood effects on health are almost exclusively limited to developed countries where residential environments with higher socioeconomic position are associated with better health, after adjusting for individual socioeconomic position [7]. Less deprived neighborhoods may have better access to health promoting resources such as recreational facilities and infrastructure, transportation, and healthy food stores. Few studies have examined this association in developing countries. In Argentina, lower area-level education was associated with higher BMI after adjusting for individual income and education in men and women, even though the association with individual-level socioeconomic position was not significant in men [14]. This same study found no area-level association with physical activity or diet in Argentina [14]. The neighborhood socioeconomic position indicator we used may not appropriately capture the environmental variation relevant to the risk factors we studied. It is also possible that there is less environmental heterogeneity in our sample than in other contexts or studies.

The findings of our study have important social implications for the city of Belo Horizonte. Socioeconomic disparities are highly prevalent and persistent in Brazil, especially in urban areas [50]. The social patterning of cardiovascular disease risk factors and behaviors in Brazil is evolving to mirror the cardiovascular health profile of developed countries with the poor being at the greatest disadvantage. These shifts may result in a double burden of high chronic and infectious disease levels in these populations [51], serving only to widen the already large gap between the poor and wealthy in Brazil and decrease the social mobility of those with the lowest socioeconomic position [50]. Without policies and interventions to address the cycle of poverty and poor health, this ever-increasing inequality could have substantial future economic and social costs for Brazil.

Our study had a number of strengths including a large sample size that was representative of an urban center in Brazil, the use of a validated survey to measure both leisure and occupational physical activity, the measurement of height and weight by a trained interviewer, and the inclusion of both individual and contextual measures of socioeconomic position. Our study also had limitations. The cross-sectional design precludes us from studying the possible causal interrelations between education, household income, and neighborhood income. These three variables are undeniably linked, and cross-sectional data prohibits the investigation of their sequencing. Furthermore, education, household income, and neighborhood income are limited measures of socioeconomic position, and future analysis could include additional variables such as occupation, wealth, and more specific and targetable neighborhood measures. In addition, we restricted our analysis to the Barreiro and West districts of Belo Horizonte, which may affect the external validity of our findings. We also used census tracts, which are variable in size, as a proxy for neighborhoods. However, this has been done in previous studies, and we were still able to detect associations at the neighborhood level. Additionally, the scope of the survey allowed us to gather only limited data on diet. Furthermore, due to missing data, we excluded 130 participants from our final sample; this exclusion has the potential to introduce bias if the examined associations in the excluded participants differ from the associations in the included participants. It is also worth noting that the survey was carried out in 2009, and the magnitude of the associated variables, or even the definition of variables themselves, may have undergone changes from 2009 to the present.

Our study identified the social patterning of various cardiovascular disease risk factors and behaviors in a large Brazilian city. BMI and obesity were inversely associated with education in women, and BMI was positively associated with income in men. In addition, physical inactivity and poor diet were associated with lower incomes and less education independently in both genders. In contrast, neighborhood income was not consistently related to health. Longitudinal analysis of this patterning is necessary to understand the causes of non-communicable diseases in the Latin American context. Understanding the drivers of these patterns will allow for the development of appropriate policy and interventions that address these health disparities.

Resumen

La prevalencia de la obesidad está aumentando en los países en desarrollo. Estudios sobre la distribución social de la obesidad y sus factores de riesgo en ciudades de América Latina cuentan con resultados inconsistentes. En este estudio se analizó una encuesta de adultos de Belo Horizonte, Minas Gerais, Brasil. Se utilizaron modelos marginales para examinar la asociación entre educación, ingresos del hogar y barrio sí como el índice de masa corporal (IMC), la obesidad, la inactividad física, y el consumo de frutas y verduras. Se observaron relaciones inversas entre el IMC, obesidad y la educación en las mujeres, así como una relación positiva entre el IMC y los ingresos del hogar y barrio en el caso de los hombres. Además, el consumo bajo de frutas y verduras y la inactividad física se asociaron inversamente con la educación y los ingresos del hogar en ambos sexos. La inactividad física se asoció inversamente con los ingresos del barrio en los hombres. Comprender las causas de esta distribución social es importante para reducir el riesgo de enfermedades cardiovasculares en las ciudades de América Latina.

Factores Socioeconómicos; Índice de Masa Corporal; Obesidad; Salud Urbana

Contibutors

J. Ward analyzed the data and wrote the manuscript. A. A. L. Friche contributed to the design and acquisition of the data, assisted with data analysis and translation of the abstract to Portuguese, and reviewed the final manuscript. W. T. Caiaffa contributed to the design and acquisition of the data, assisted with data interpretation, and reviewed the final manuscript. F. A. Proietti and C. C. Xavier contributed to the design and acquisition of the data and reviewed the final manuscript. A. V. Diez Roux contributed to the design and acquisition of the data, assisted with data analysis and interpretation and translation of the abstract to Spanish, and reviewed the final manuscript.

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