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Educational inequalities in obesity, abdominal obesity, and metabolic syndrome in seven Latin American cities: the CARMELA Study

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Abstract

Aims: Earlier reviews have found that the proportion of inverse associations between socioeconomic status and obesity increased according to the level of development of the studied country. Based on this finding, it has been hypothesized that in low- to middle- income countries the burden of obesity shifts to disadvantaged groups as a country develops.
Methods and results: CARMELA is a cross-sectional, population-based observational study that sampled 11,550 women and men age 25–64 from seven major Latin American cities. We analyzed by gender the association of educational attainments (as proxy of socioeconomic status) with body mass index, waist circumference and metabolic syndrome. Participating cities were divided by country Human Development Index (HDI). An inverse gradient between socioeconomic status and body mass index in women was uniformly present in High HDI cities (Buenos Aires, Santiago, Mexico) but not in Medium HDI group (Barquisimeto, Bogota, Lima, Quito), where two cities showed an inverse gradient and two cities did not. In men, no clear socioeconomic gradients were found. Findings regarding waist circumference and metabolic syndrome closely mirrored those about body mass index.
Conclusion: In women but not men, these results give support to the hypothesis of obesity shifting to the poor and extend it to the related concepts of abdominal obesity and metabolic syndrome. Obesity should be considered as a socially-generated disease and an indicator of socioeconomic disadvantage, to be approached by comprehensive strategies that bear in mind this perspective.

Keywords
Obesity, metabolic syndrome, prevalence, developing countries, Latin America, socioeconomic, educational level, inequalities, women

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Introduction

The obesity pandemic, initially limited to the developed world, has penetrated to countries at lower levels of economic development.[1]

In the developed Western countries, obesity in women is inversely associated to socioeconomic status (SES), whereas in the developing world the opposite has been found, according to Sobal and Sunkard's landmark review.[2] More recently, the updated reviews by McLaren[3] and Monteiro et al.[4] have given support to a different general postulate: that the burden of adult obesity in low- or middle-income countries tends to

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shift towards the groups with lower SES as the country develops. To support her hypothesis, McLaren[3] demonstrated that the overall pattern was of an increasing proportion of direct associations between SES and obesity and a decreasing proportion of inverse associations as one moves from countries with high levels of socioeconomic development to countries with medium and low levels of development. This author established the postulates for both genders; however, most referenced publications about men in her review found no SES–obesity association. Monteiro et al.[4] added to the construct by suggesting that the shift of obesity towards disadvantaged women may occur at an earlier stage of the country's socioeconomic development than it does for men. In developed countries, an inverse socioeconomic gradient (stronger in women) for MS (metabolic syndrome) and abdominal obesity has been similarly found, first in the Whitehall II study,[5] and later in several other studies.[6–9] Given that the metabolic derangements linked to abdominal obesity may mediate cardiometabolic risks related to obesity,[10] this issue deserves consideration.

Latin America is going through a rapid demographic and nutritional transition,[11] and the above-mentioned process of obesity becoming a disease of the poor should be observed there. The Cardiovascular Risk Factor Multiple Evaluation in Latin America (CARMELA) study[12] included adult subjects from seven major Latin American cities (Barquisimeto, Venezuela; Bogota, Colombia; Buenos Aires, Argentina; Lima, Peru; Mexico City, Mexico; Quito, Ecuador; and Santiago, Chile) and allows for evaluation of the socioeconomic gradient of cardiovascular risk factors in representative samples of urban populations from different countries of the region.

The purpose of the present work is to analyze the association between SES and parameters of obesity, abdominal obesity and metabolic syndrome in urban women and men of CARMELA cities. Following the referred postulates,[3] we hypothesized that in women there would be inverse, graded associations of SES with the aforementioned risk factors according to the development level of the corresponding country, with more frequent inverse associations in the group of more developed countries and less frequent inverse associations in the group of less developed countries.

Methods

Study design

CARMELA is a cross-sectional, population-based observational study conducted in the above-mentioned seven cities between April 2004 and August 2005. This study complied with the Declaration of Helsinki, Guidelines for Good Clinical Practice, and local bioethics regulations and laws. Subjects provided written informed consent.

Sampling strategy

CARMELA was designed to enroll approximately 1600 participants per city, aged 25–64, stratified by sex and age (10-year groups) in a multistage probabilistic design. Cities were first divided into geographic sectors, then into primary sampling units (city blocks or other appropriate areas), which were randomly selected for further sampling. A systematic sample was obtained from households present in selected primary sampling units, with oversampling of older groups. Anyone within the age limits residing at selected addresses was eligible for inclusion; subjects were included only if they completed the survey and clinical visit. Exclusion criteria comprised persons residing at addresses that were not households or in marginal areas considered dangerous for interviewers. Non-response rates were as follows: Barquisimeto 9.8 per cent, Bogotá 35.5 per cent, Buenos Aires 33.5 per cent, Lima 36.0 per cent, Mexico City 25.8 per cent, Quito 39.4 per cent, and Santiago 35.7 per cent.

Measurements and definitions

Trained interviewers administered a questionnaire about demographics, educational attainments, and cardiovascular risk factors. Anthropometric, clinical, and biochemical measurements, and carotid ultrasonography were obtained from every study participant. Subjects' height (without footwear) was measured with a vertical measuring scale equipped with a right angle accessory. Weight and waist circumference were measured with subjects wearing only undergarments. Waist circumference was measured at the midpoint between the last rib and the iliac crest.

Self-reported educational level attained was our indicator of SES, classified into three ordinal categories. 'Less than high school' included those who had never been to high school or had not completed it. 'High school' included those who had completed high school but not attained a university degree. 'University degree' included those who had completed a university degree.

We analyzed BMI and WC (waist circumference) as continuous variables because using cut-off points might introduce a statistical artefact in transitional countries where BMI distribution may not have shifted sufficiently to the right to tip many individuals beyond the defined threshold for obesity.[13] Metabolic syndrome was defined by NCEP ATP III criteria[14] as three or more of the following: waist >102 cm (men), >88 cm (women); triglycerides ≥ 150 mg/dl; high density lipoprotein cholesterol (HDL-C) <40 mg/dl (men), <50 mg/dl (women); blood pressure $\geq 130/85$ mmHg;

and fasting plasma glucose ≥110 mg/dl or self-reported diabetes.

Country-level indicators

We used the 2005 Human Development Index (HDI) assigned by the United Nations Development Program (UNDP)[15] to classify the level of development for each city. This program ranks countries according to life expectancy at birth, school enrollment and adult literacy, and GDP per capita, and divides them into three groups: High Human Development (HDI ≥ 0.800), Medium Human Development (HDI 0.500–0.799), and Low Human Development countries (HDI <0.500).

Statistical analysis

Age and sex distributions for the seven cities were summarized as mean ± SD or frequencies and percentages. Statistical processing addressed the non-equal probability character of the sample and the structure of the design to generate data adjusted for the age and sex distribution of the population of each city. Therefore, weighted means and prevalences along with their 95% CIs were estimated by survey analysis procedures, taking into account the multistage stratified sampling design. The analyses of BMI, WC, and MS according to educational levels were also adjusted for age as a continuous variable. High educational level was used as reference category for statistical comparison. Contrast *p*-values and *p*-values for trend were reported, and for BMI and WC mean values educational level by gender interaction was also explored. All the analyses were performed using SAS Software (Release 9.1, Cary, NC, USA). *p*-values less than 0.05 were considered significant.

Results

Population

According to the UNDP program,[15] Argentina, Chile, and México fell into the High Human Development cluster (HDI 2005: 0.869, 0.867, and 0.829, respectively), and Venezuela, Colombia, Peru, and Ecuador into the Medium Human Development (HDI 2005: 0.792, 0.791, 0.773, and 0.772, respectively). Table 1 shows the basic characteristics of interest of the 11,550 CARMELA participants.

Anthropometric indicators and SES

Table 2 displays weighted means and 95 per cent confidence intervals of BMI and WC by educational category for each city. Supporting our hypothesis, in women there was an inverse graded relationship of educational level with both indicators in the three cities in the high HDI cluster (Buenos Aires, Santiago, and Mexico City) but only in half of the cities in the medium HDI cluster (Lima and Quito). Regarding men, in most cases there were no associations between educational level and BMI or WC, with a few exceptions.

In the same table we also report on formal tests of SES-by-gender interaction. In Santiago, Mexico City, Lima, and Quito the interaction terms SES-by-gender were highly statistically significant. In Buenos Aires, the interaction terms were significant, meaning a stronger association in women than in men. Moreover, in Bogota the interaction terms were also significant even when the test for trend showed only a non-significant tendency to inverse associations in women for BMI and WC. Lastly, in Barquisimeto the interaction was at the limit of statistical signification regarding WC, reflecting in this case the existence of a neutral association in women but a direct one in men.

Metabolic syndrome and SES

Table 3 displays the age-adjusted MS weighted prevalence and 95 per cent confidence intervals in each city according to educational level. As was the case with regard to BMI and WC, in women there was a clear inverse, graded association of SES and MS in the three cities of the high HDI cluster, but only in two out of four cities in the medium HDI cluster. Once again, in most analyses of men we found no significant socioeconomic gradient, without a clear pattern in relation to the stage of a country's development.

Discussion

In seven major Latin American cities, we found an inverse, graded association between SES and obesity, abdominal obesity, and MS in women of every population from High Human Development countries, but only in half of the populations from less developed countries. In women, these findings support McLaren's[3] postulate of the gradual reversal of the social gradient in weight: as one moves downwards from high- to medium- or low- HDI countries, the proportion of direct associations between obesity and SES increases and the proportion of inverse associations decreases. Our results also extend this postulate to abdominal obesity and MS. In men, no clear relationship was detected between social gradient for markers of adiposity and level of country development. In almost every participating city, whatever its development level, there was interaction by gender, meaning that women were more susceptible than men to the risks of low-SES.

Table 1. Relevant participant characteristics from the seven cities

	High Human Development cluster			Medium Human Development cluster			
	Buenos Aires	Santiago	Mexico City	Barquisimeto	Bogota	Lima	Quito
N	1482	1655	1722	1848	1553	1652	1638
Men (*N*, %)	734 (49.5)	783 (47.3)	833 (48.4)	713 (38.6)	738 (47.6)	769 (46.6)	813 (49.6)
Mean age $\pm$ SD (years)	44.6 $\pm$ 11.7	44.8 $\pm$ 11.2	44.5 $\pm$ 11.3	45.1 $\pm$ 11.3	45.1 $\pm$ 11.3	43.6 $\pm$ 11.6	44.4 $\pm$ 11.2
Higher educational level attained, women							
Less than high school (*N*, %)	195 (24.7)	407 (42.8)	246 (22.3)	842 (68.5)	512 (55.4)	179 (18.4)	532 (57.2)
High school (*N*, %):	390 (52.8)	379 (47.1)	477 (55.2)	232 (25.4)	254 (37.4)	533 (62)	226 (33.4)
University degree (*N*, %):	163 (22.4)	86 (10)	166 (22.6)	62 (6.1)	49 (7.1)	171 (19.6)	67 (9.4)
Higher educational level attained, men							
Less than high school (*N*, %)	194 (25.2)	306 (34.9)	131 (11.2)	490 (63.6)	429 (54.6)	86 (9.4)	417 (47.2)
High school (*N*, %):	386 (53.9)	361 (50.2)	399 (50.1)	195 (32.7)	241 (36.3)	476 (65.6)	230 (32.1)
University degree (*N*, %):	154 (20.9)	116 (14.9)	303 (38.8)	28 (3.6)	68 (9.2)	207 (25)	166 (20.7)
Body mass index (kg/m^2, 95%CI)							
Women	25.6 (25.1–26.1)	28 (27.6–28.4)	28.2 (27.7–28.6)	27 (26.5–27.5)	26.8 (26.4–27.1)	27.3 (26.9–27.6)	27 (26.4–27.5)
Men	27.1 (26.8–27.4)	27.5 (27.2–27.8)	28.1 (27.8–28.5)	26.9 (26.3–27.5)	25.7 (25.4–26.0)	26.9 (26.6–27.3)	25.6 (25.3–25.9)
Waist circumference (cm, 95%CI)							
Women	83.6 (82.5–84.7)	87.9 (87.0–88.8)	91.2 (90.1–92.3)	84.9 (84.0–85.9)	84.6 (83.8–85.4)	83.8 (82.9–84.7)	85.4 (84.2–86.7)
Men	95.3 (94.4–96.2)	93.5 (92.7–94.4)	98.4 (97.1–99.7)	92.6 (91.0–94.1)	90.2 (89.2–91.1)	89.5 (88.5–90.5)	87.4 (86.7–88.1)
Metabolic syndrome prevalence (%, 95%CI)							
Women	12.3 (9.6–15.1)	23.0 (20.0–26.0)	28.0 (24.4–31.6)	25.6 (22.9–28.3)	21.7 (19.0–24.4)	20.0 (17.3–22.8)	20.1 (16.9–23.4)
Men	21.7 (19.0–24.4)	19.0 (16.3–21.6)	26.3 (22.9–29.6)	26.3 (22.3–30.2)	18.7 (15.8–21.6)	15.8 (13.0–18.6)	7.5 (5.6–9.3)

All data reported as means or percentages, except for the variables gender and age, refer to weighted means or prevalence. Cities in descendent order according to HDI of corresponding country.[15]
Metabolic syndrome, according to ATP III criteria.[14]

Table 2. Age-adjusted weighted mean (95%CI) for body mass index and waist circumference according to educational level in the seven cities (by gender)

	High Human Development cluster			Medium Human Development cluster			
	Buenos Aires	Santiago	Mexico City	Barquisimeto	Bogota	Lima	Quito
Body mass index (kg/m^2)							
Women							
Less than high school	26.7 (25.9–27.5)[a]	29.3 (28.7–30.0)[a]	29.5 (28.7–30.3)[a]	27.3 (26.9–27.7)	27.5 (27.1–28.0)	29.4 (28.8–30.0)[a]	28.1 (27.5–28.7)[a]
High school	26 (25.4–26.6)[a]	27.8 (27.2–28.3)[a]	28.4 (27.9–28.8)[b]	27.4 (26.4–28.5)	27.1 (26.5–27.7)	27.4 (27.0–27.9)	26.9 (26.1–27.7)[b]
University degree	24.3 (23.7–24.9)	25.6 (24.7–26.4)	27.4 (26.6–28.1)	27.8 (25.9–29.6)	26.5 (25.5–27.6)	26.7 (26.0–27.4)	25.5 (24.5–26.6)
p for trend	<0.001	<0.001	0.0002	0.692	0.798	<0.001	<0.001
Men							
Less than high school	27.9 (27.3–28.6)[b]	27.3 (26.9–27.8)	28.3 (27.4–29.2)	26.8 (26.3–27.4)	25.9 (25.6–26.2)	26.9 (26.1–27.8)	26 (25.6–26.4)
High school	27.1 (26.7–27.4)	27.9 (27.5–28.3)	28.5 (28.0–29.0)	27.7 (26.7–28.7)	26 (25.5–26.5)	27.2 (26.7–27.6)	25.7 (25.2–26.2)
University degree	27 (26.4–27.7)	27.7 (26.8–28.6)	28.1 (27.6–28.6)	26.6 (25.0–28.1)	26.3 (25.6–27.1)	27.1 (26.4–27.8)	25.6 (25.0–26.2)
p for trend	0.039	0.228	0.512	0.242	0.385	0.852	0.229
p for gender interaction	0.010	<0.001	0.002	0.253	0.031	<0.001	<0.001
Waist circumference (cm)							
Women							
Less than high school	86.5 (84.7–88.4)[a]	90.7 (89.4–92.1)[a]	93.5 (91.6–95.5)[a]	86.1 (85.3–87.0)	86.8 (85.8–87.9)	88.8 (87.3–90.4)[a]	88.5 (87.2–89.8)[a]
High school	84.3 (82.9–85.7)[a]	87.5 (86.4–88.7)[a]	91.7 (90.4–92.9)	85.5 (83.5–87.6)	85.4 (84.3–86.6)	84 (82.9–85.0)[b]	84.8 (83.1–86.5)[a]
University degree	80.6 (79.1–82.1)	82.5 (80.8–84.1)	89.6 (87.6–91.6)	84.6 (80.5–88.8)	85.6 (83.5–87.7)	81.7 (80.1–83.3)	81.7 (79.6–83.8)
p for trend	<0.001	<0.001	0.001	0.490	0.087	<0.001	<0.001
Men							
Less than high school	97.5 (95.8–99.1)	92.8 (91.6–94.1)[a]	97.3 (95.3–99.3)[b]	92.4 (91.1–93.6)	91.1 (90.4–91.9)	90 (87.7–92.3)	88.1 (87.1–89.0)
High school	95.8 (94.7–96.9)	94.9 (93.9–95.8)	98.6 (97.2–100.0)	95.6 (93.1–98.1)	91.4 (90.1-92.8)	90.2 (89.1–91.3)	88.1 (86.7–89.5)
University degree	95.7 (93.9–97.4)	96.2 (94.0–98.3)	100.4 (98.7–102.1)	94.3 (90.7–98.0)	92.8 (90.8–94.7)	90.5 (88.8–92.1)	88.4 (86.9–90.0)
p for trend	0.110	0.003	0.009	0.014	0.191	0.726	0.720
p for gender interaction	0.024	<0.001	<0.001	0.056	0.040	<0.001	<0.001

Cities in descendent order according to HDI of corresponding country.[15] [a]$p < 0.01$ as compared with reference group of the same city (university degree). [b]$p < 0.05$ as compared with reference group of the same city (university degree).

Table 3. Age-adjusted weighted prevalence (%, with 95%CI) of metabolic syndrome according to educational level by city and gender

	High Human Development cluster			Medium Human Development cluster			
	Buenos Aires	Santiago	Mexico City	Barquisimeto	Bogota	Lima	Quito
Women							
Less than high school	13.5 (8.9–19.9)[a]	30.4 (25.3–36.0)[a]	40.9 (33.6–48.7)[a]	29.6 (26.4–33.1)	26 (21.2–31.4)	31.8 (25.3–39.0)[a]	26.7 (21.8–32.2)[a]
High school	11.7 (8.5–15.8)[b]	20.6 (16.5–25.4)	29.8 (26.4–33.4)	27.2 (21.1–34.5)	23 (18.3–28.5)	21.3 (17.7–25.5)	17.8 (12.4–24.8)
University degree	5.2 (2.8–9.7)	13.9 (7.8–23.3)	21 (14.5–29.3)	26.4 (16.4–39.6)	21 (11.3–35.6)	15.7 (10.3–23.0)	13.9 (7.3–25.0)
p for trend	0.013	0.007	<0.001	0.523	0.383	<0.001	0.012
Men							
Less than high school	28.9 (23.4–35.1)[a]	18.6 (14.6–23.4)	26.4 (20.1–33.9)	29.5 (25.0–34.5)[a]	21.3 (17.3–26.1)	19.2 (11.9–29.5)	8.1 (5.5–12.0)
High school	20.6 (17.1–24.6)	19.9 (15.8–24.8)	27.8 (23.0–33.3)	31.3 (24.0–39.7)[a]	18.6 (14.0–24.2)	18 (14.6–22.0)	8.8 (5.5–13.9)
University degree	17.8 (13.1–23.7)	24.7 (17.3–33.9)	29.7 (25.2–34.6)	9.2 (3.3–23.3)	20.7 (12.9–31.5)	13.7 (9.7–18.9)	7.2 (4.0–12.8)
p for trend	0.003	0.221	0.435	0.391	0.598	0.108	0.814

Cities in descendent order according to HDI of corresponding country.[15] Metabolic syndrome defined according to ATP III criteria.[14] [a]$p < 0.01$ as compared with reference group of the same city (university degree). [b]$p < 0.05$ as compared with reference group of the same city (university degree).

The relevance of these findings lies in that current theoretical constructs about socioeconomic inequalities with regard to obesity are extended to the related figures of abdominal obesity and MS and have been confirmed in a population-based study from seven major cities of different countries of Latin America with highly comparable measurements.

Plausible explanations are complex. In low developed countries, poor people have difficulties in accessing food and so they can hardly be obese. When a certain stage of economic development is achieved, food becomes more accessible for the majority of the poor and then the process of shifting the burden of obesity to the disadvantaged as the country develops may start.[1] The nutritional transition – characterized by an increase of the energy density of diets, associated with changes in physical activity leading to sedentarism, and fuelled by large-scale societal and nutritional changes[16] – creates an obesogenic environment that selectively affects poor people who are more constrained in their choices.[17]

The SES inverse gradient for obesity and related disorders was clearer in women than in men. Possible reasons for these gender differences include: parity, which is associated with a persistent increment of weight and waist girth;[18] more social stigmatization in obese women, so limiting their social upward mobility;[19] and depression related to low SES, which seems to affect women more than men[20] and can origin or increase depression-related obesity.[21] Whatever the reasons, women are a population at particular psychosocial risk.

This study has some limitations. Firstly, cross-sectional studies cannot consider temporal or causal implications; nevertheless, they are normally used to study the SES–obesity association. Secondly, the exclusion of unsecure areas may have affected the socioeconomic balance of the sample; it could have occurred in Lima, where the included subjects had a relatively high educational level (as compared with the other six CARMELA cities), what is unexpected in a country of medium HDI and suggests selection bias towards more advantaged subgroups. Thirdly, CARMELA only includes urban populations and the results are not applicable to rural people.

Our data suggest than in developing countries, the growing burden of obesity and its undesirable metabolic consequences will selectively affect disadvantaged women in the near future. The challenge of interpreting these results is where to emphasize; whether on general public health and reducing inequalities, or on a medical approach of cardiovascular risk assessment and management. The association of obesity (and its related equivalents, abdominal obesity and MS) and SES has to be interpreted as a warning not for an abundance of medically orientated measures, but to focus the attention of society on its capacity for creating its own disease burden by maintaining inequality. Interventions from a comprehensive societal perspective should be the most appropriate way to deal with this problem.

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Conflict of interest

The authors do not have relevant financial interests to disclose regarding this article.

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