Obesity and its Relation With Diabetes and Hypertension

A Cross-Sectional Study Across 4 Geographical Regions

Shivani A. Patel*, Mohammed K. Ali*, Dewan Alam[†], Lijing L. Yan[‡,§], Naomi S. Levitt[‖,¶], Antonio Bernabe-Ortiz[#], William Checkley**, Yangfeng Wu[‡,††], Vilma Irazola[‡‡], Laura Gutierrez[‡‡], Adolfo Rubinstein[‡‡], Roopa Shivashankar[§§], Xian Li[‡], J. Jaime Miranda[#,‖‖], Muhammad Ashique Haider Chowdhury[¶¶], Ali Tanweer Siddiquee[¶¶], Thomas A. Gaziano[##,***], M. Masood Kadir[†††], Dorairaj Prabhakaran[§§]

Atlanta, GA, USA; Toronto, Ontario, Canada; Beijing, China; Kunshan, China; Cape Town, South Africa; Lima, Peru; Baltimore, MD, USA; Buenos Aires, Argentina; New Delhi, India; Dhaka, Bangladesh; Cambridge, MA, USA; Boston, MA, USA; and Karachi, Pakistan

ABSTRACT

Background: The implications of rising obesity for cardiovascular health in middle-income countries has generated interest, in part because associations between obesity and cardiovascular health seem to vary across ethnic groups.

Objective: We assessed general and central obesity in Africa, East Asia, South America, and South Asia. We further investigated whether body mass index (BMI) and waist circumference differentially relate to cardiovascular health; and associations between obesity metrics and adverse cardiovascular health vary by region.

Methods: Using baseline anthropometric data collected between 2008 and 2012 from 7 cohorts in 9 countries, we estimated the proportion of participants with general and central obesity using BMI and waist circumference classifications, respectively, by study site. We used Poisson regression to examine the associations (prevalence ratios) of continuously measured BMI and waist circumference with prevalent diabetes and hypertension by sex. Pooled estimates across studies were computed by sex and age.

Results: This study analyzed data from 31,118 participants aged 20 to 79 years. General obesity was highest in South Asian cities and central obesity was highest in South America. The proportion classified with general obesity (range 11% to 50%) tended to be lower than the proportion classified as centrally obese (range 19% to 79%). Every standard deviation higher of BMI was associated with 1.65 and 1.60 times higher probability of diabetes and 1.42 and 1.28 times higher probability of hypertension, for men and women, respectively, aged 40 to 69 years. Every standard deviation higher of waist circumference was associated with 1.48 and 1.74 times higher probability of diabetes and 1.34 and 1.31 times higher probability of hypertension, for men and women, respectively, aged 40 to 69 years. Associations of obesity measures with diabetes were strongest in South Africa among men and in South America among women. Associations with hypertension were weakest in South Africa among both sexes.

Conclusions: BMI and waist circumference were both reasonable predictors of prevalent diabetes and hypertension. Across diverse ethnicities and settings, BMI and waist circumference remain salient metrics of obesity that can identify those with increased cardiovascular risk.

Survey data show that mean body mass index (BMI) increased worldwide by 0.4 kg/m^2 per decade between 1980 and 2008, corresponding with a doubling of worldwide obesity prevalence from 6% in 1980 to 12% in 2008 [1,2]. The global increasing trend in BMI has drawn attention to the problem of over nutrition. Although anthropometric measures of obesity may be simple, inexpensive, and feasible tools to classify cardiovascular health in the absence of costly laboratory tests, the specific implications of excess weight on population-level cardiovascular disease risk, events, and mortality remain unclear. For example, several authors argue that the relation between obesity measures and cardiovascular health and mortality varies by ethnic group [3–6]. Which metric of obesity (e.g., BMI, waist circumference) best relates to cardiovascular health also remains an issue [7–10].

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From the *Hubert Department of Global Health, Emory University, Atlanta, GA, USA, and the Centre for Control of Chronic Conditions, New Delhi, India; [†]Centre for Global Health Research, Li Ka Shing Knowledge Institute, Toronto, Ontario, Canada, and Faculty of Health Sciences, York University, Toronto, Ontario, Canada; [‡]The George Institute for Global Health at Peking

University Health Science Center, Beijing, China; [§]Duke Global Health Institute, and Global Health Research Center, Duke Kunshan University, Kunshan, China; [‖]Chronic Disease Initiative for Africa (CDIA), University of Cape Town, Cape Town, South Africa; [¶]Division of Diabetic Medicine and Endocrinology, University of Cape Town, Cape Town, South Africa; [#]CRONICAS Center of Excellence in Chronic Diseases, Universidad Peruana Cayetano Heredia, Lima, Peru; **Division of Pulmonary and Critical Care, School of Medicine, Johns Hopkins University, Baltimore, MD, USA; [††]Department of Epidemiology and Biostatistics, Peking University School of Public Health, Beijing, China; [‡‡]South American Center of Excellence for Cardiovascular Health (CESCAS), Institute for Clinical Effectiveness and Health Policy (IECS) Buenos Aires, Argentina; [§§]Public Health Foundation of India (PHFI), the Centre for Chronic Disease Control, and the Centre for Control of Chronic Conditions, New Delhi, India; [‖‖]Department of Medicine, School of Medicine, Universidad Peruana Cayetano Heredia, Lima, Peru; [¶¶]Chronic Non-Communicable Disease Unit (CNCDU), Center for Equity and Health Systems (CEHS), ICDDR, Dhaka, Bangladesh; [##]Brigham & Women's Hospital, Harvard School of Public Health, Harvard University, Cambridge, MA, USA; ***Division of Cardiovascular Medicine Brigham & Women's Hospital, Boston, MA, USA; [†††]Department of Community Health Sciences, The Aga Khan University, Karachi, Pakistan. Correspondence: S. A. Patel (s.a.patel@emory.edu).

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In the context of middle-income countries (MICs), resolving these concerns is pressing because the bulk of the knowledge base regarding the relation of obesity and cardiovascular health has been generated from cohorts of composed of select ethnic backgrounds [11] and/or populations in high-income settings [12] that are exposed to different environments compared with residents of MICs. Important contributions regarding diverse populations in MICs have come from case-control study designs [13] or large-scale pooling projects relying on relatively older data sources [7]. As such, studying different weight-related measures and how they relate to each other across diverse populations and settings using current data contributes to the discourse regarding appropriate indicators for weight monitoring and control.

Using cross-sectional data collected between 2008 and 2012, we report the prevalence of obesity in 9 countries in 4 broad geographic regions: Africa, East Asia, South America, and South Asia. Further, we aimed to address two dimensions of controversy in the weight status literature by investigating whether (1) general (BMI) and central (waist circumference) obesity differentially relate to cardiovascular health and (2) adverse cardiovascular health associated with a given level of obesity was consistent across 4 geographic regions.

METHODS

Study design and participants

We used recent cross-sectional data (collected in 2008 and 2009 in South Africa and in 2010 through 2012 for other countries) from adult populations with objectively assessed height, weight, and waist measurements. The studies have been described in detail previously [14—19]. Briefly, population-based sampling was used to identify and recruit participants ages 18 and older (exact age inclusion varied by study) in a total of 19 sites in South Africa, China, Argentina, Chile, Peru, Uruguay, Bangladesh, India, and Pakistan. The 5 provinces sampled in the China study were combined into 1 group because those sites were selected to be homogenous and represent rural locales in northern China. A total of 36,236 individuals were enrolled at baseline across the studies and included in a harmonized dataset following methodology described elsewhere in this issue [20]. This analysis was restricted to men and women aged 20 to 79 years of age at baseline (561 excluded) with complete anthropometric assessments (4,487 excluded), for a total study sample of 31,118. Table 1 lists the populations represented in this study.

Obesity metrics and definitions

We examined both general and central obesity, defined using BMI (measured as weight in kilograms divided by the square of height in meters) and waist circumference thresholds, respectively. "General obesity" was defined using World Health Organization International thresholds of BMI > 30 kg/m^2, and "overweight" was defined as $25 <$ BMI ≤ 30 kg/m^2 [21]. For ethnic-specific general obesity, we modified the thresholds to define BMI > 25 kg/m^2 as obese and BMI > 23 kg/m^2 as overweight among East and South Asian participants [4]; classification for all other participants followed international thresholds. "Central obesity" was defined using the International Diabetes Federation recommendations of waist circumference of >94 cm in men of Caucasian and African ancestry and >80 cm in women of all ethnic backgrounds [22]. For East and South Asian men, central obesity was defined waist circumference of >90 cm [22]. We also considered BMI and waist as continuous (linear) indicators of obesity in regression analyses. The China study did not collect waist circumference data and was excluded from analyses of central obesity.

Cardiovascular health indicators

Diabetes and hypertension status were investigated as indicators of cardiovascular health. Diabetes was defined as laboratory-measured fasting blood glucose of ≥126 mg/dl, current use of diabetes medication, or previous diagnosis of diabetes based on self-report. A participant was classified as having diabetes if she or he had any of the 3 diabetes indicators. Diabetes classification was based solely on self-report in China and Bangladesh, neither of which had objectively measured diabetes indicators. Hypertension was defined as measured systolic blood pressure of ≥140 mm Hg or diastolic blood pressure of ≥90 mm Hg or taking medication for hypertension. The Bangladesh study did not include questions regarding use of hypertension medication, so hypertension was defined using measured blood pressure only.

Statistical analysis

The demographic composition and distribution of anthropometry and cardiovascular health indicators was described by site. Proportions obese were reported by site and sex, and were standardized to the World Health Organization standard population structure [23]. The proportion underweight as well as the proportion obese in each age group (20 to 34, 35 to 49, 50 to 64, and 65 to 79 years) was also estimated in each site by sex in supplemental analyses. Estimation by age group was restricted to sites with 20 or more participants in the respective age group.

Graphical examination of the relation between deciles of BMI and waist circumference and diabetes and hypertension indicated linear relationships between exposures and outcomes. We thus treated BMI and waist circumference as continuous variables in further analysis. Both obesity measures were standardized to have mean of 0 and a standard deviation of 1 to facilitate comparisons of effect size estimates associated with each.

We used Poisson regression models with robust variance estimation to estimate the relative prevalence and 95% confidence interval of each cardiovascular health indicator (i.e., diabetes and hypertension) as a function of each obesity

TABLE 1. Sample characteristics

Region and Site	Sample size	Demographics			Anthropometry		Cardiovascular health indicators					
		Age, yrs, min-max	Male, %	Any education, %	BMI, kg/m^2	Waist circumference, cm	FPG, mg/dl	HbA1c, %	Self-reported diabetes, %	SBP, mm Hg	DBP, mm Hg	Hypertension medication, %
Africa												
Cape Town, South Africa [8]	1,088	39.9 (22-75)	36.4	88.8	28.9 ± 0.2	91.2 ± 0.5	94.3 ± 1.2	n/a	7.6	123.6 ± 0.7	81.1 ± 0.4	18.2
East Asia												
Northern China, China [17]	5,666	55.5 (20-79)	51.2	81.7	24.3 ± 0.1	n/a	n/a	n/a	9.1	141.4 ± 0.3	86.1 ± 0.2	25.3
South America												
Bariloche, Argentina [16]	1,987	48.0 (30-79)	47.9	99.6	28.1 ± 0.1	93.6 ± 0.3	92.3 ± 0.5	n/a	5.4	125.1 ± 0.4	84.9 ± 0.3	16.0
Marcos Paz, Argentina [16]	1,973	47.4 (33-78)	50.3	98.4	29.7 ± 0.2	96.6 ± 0.4	100.3 ± 0.9	n/a	6.5	125.8 ± 0.5	80.8 ± 0.3	21.1
Temuco, Chile [16]	1,944	47.1 (31-77)	46.5	99.6	28.9 ± 0.1	96.1 ± 0.3	98.7 ± 0.7	n/a	9.8	123.7 ± 0.5	80.8 ± 0.3	18.5
Canelones, Uruguay [16]	1,562	48.5 (32-76)	49.1	99.6	28.2 ± 0.2	97.1 ± 0.4	94.0 ± 0.6	n/a	9.7	126.9 ± 0.5	81.1 ± 0.3	23.2
Lima, Peru [14]	1,018	50.7 (35-79)	48.4	94.9	28.4 ± 0.1	92.4 ± 0.4	97.0 ± 1.0	5.8 ± 0.0	6.8	115.5 ± 0.5	72.6 ± 0.4	13.5
Puno (rural), Peru [14]	554	51.1 (35-79)	46.5	93.1	25.4 ± 0.2	85.9 ± 0.5	89.3 ± 0.8	5.8 ± 0.0	2.0	116.0 ± 0.7	75.3 ± 0.4	2.2
Puno (urban), Peru [14]	546	50.8 (35-79)	48.8	97.8	28.0 ± 0.2	93.0 ± 0.5	95.3 ± 1.2	5.9 ± 0.0	4.0	111.8 ± 0.7	71.8 ± 0.4	10.3
Tumbes, Peru [14]	973	50.2 (35-79)	49.2	96.5	28.5 ± 0.2	94.4 ± 0.3	103.2 ± 1.3	6.1 ± 0.0	7.6	118.9 ± 0.6	73.4 ± 0.4	19.3
South Asia												
Dhaka, Bangladesh [19]	1,882	49.6 (40-79)	43.4	100	24.6 ± 0.1	86.8 ± 0.3	n/a	n/a	19.1	125.1 ± 0.7	82.9 ± 0.6	n/a
Matlab, Bangladesh [19]	1,805	51.5 (40-79)	43.6	99.9	20.8 ± 0.1	73.9 ± 0.2	n/a	n/a	5.7	115.1 ± 0.5	73.5 ± 0.3	n/a
Chennai, India [15]	3,348	38.6 (20-79)	39.8	92.4	25.4 ± 0.1	83.0 ± 0.3	106.0 ± 0.9	6.2 ± 0.0	16.3	121.1 ± 0.4	80.6 ± 0.3	8.5
New Delhi, India [15]	3,873	41.2 (20-79)	48.2	83.3	25.1 ± 0.1	86.6 ± 0.2	111.2 ± 0.7	6.2 ± 0.0	11.6	124.9 ± 0.3	83.4 ± 0.2	11.5
Karachi, Pakistan [15]	2,969	37.9 (20-79)	43.5	74.3	25.0 ± 0.1	86.8 ± 0.3	101.4 ± 0.7	5.9 ± 0.0	8.5	118.3 ± 0.4	79.2 ± 0.2	13.1

Values are mean ± standard error unless otherwise noted.
BMI, body mass index; DBP, diastolic blood pressure; FPG, fasting blood glucose; HbA1c, hemoglobin A1c; n/a, not available; SBP, systolic blood pressure.

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measure (i.e., BMI and waist circumference) [24,25]. All models were estimated by sex, adjusted for age in years, included a fixed effect for study site, and accounted for clustering of participants within study sites. Models with interaction terms included respective main effects.

We first estimated a pooled prevalence ratio (PR) for the overall sample among participants aged 40 to 69 years, the age group with the best coverage across studies. We next derived the site-specific association by including an interaction term between site (a 14-level categorical variable) and the obesity measure of interest. To test whether any regional patterning existed in variations across sites, we then estimated a model with an interaction term between region (a 4-level categorical variable) and the obesity measure. Generalized score statistics were used to test statistical difference in measures of associations by site and region.

We also estimated age-specific PRs by sex. Parallel to our approach above, this was done by including an interaction term between age group (a 4-level categorical variable indicating participant age of 20 to 34, 35 to 49, 50 to 64, or 65 to 79 years) and obesity measure. To assess linear trends by age group, we included an interaction term between age group treated as a discrete ordinal variable and the respective obesity measure. A p value of <.05 was considered evidence of a linear trend in PRs by age group.

As a sensitivity analysis, we also estimated each association of interest separately by study and meta-analyzed those results to produce pooled estimates and estimate measures of heterogeneity across sites [26]. Associations were largely the same, and indicated heterogeneity across the study sites (data not shown; available from the first author).

Statistical analysis was performed using SAS 9.4 Software (Cary, NC).

RESULTS

Table 1 describes the demographic, anthropometric, and cardiovascular profile of participants by study site. The ages of available participants varied from study to study. After age standardizing to the world population, the lowest mean age of 39 years observed in Chennai, India, and highest mean age of 56 years observed in northern China. The proportion of men ranged from 36% in Cape Town, South Africa to 51% in northern China, and the proportion with any education ranged from 74% in Karachi, Pakistan to 100% in urban Dhaka, Bangladesh. Mean (standard error) BMI and waist circumference was lowest in rural Matlab, Bangladesh (20.8 ± 0.1 kg/m^{2}and 73.9 ± 0.2 cm, respectively), and BMI was highest in Marcos Paz, Argentina (29.7 ± 0.2 kg/m^2) and waist circumference was highest in Canelones, Uruguay (97.1 ± 0.4 cm). Fasting blood glucose ranged from 89.3 (Rural Puno, Peru) to 111.2 mg/dl (New Delhi, India). Hemoglobin A1c was assessed at only 6 sites, and ranged from mean of 5.8 at both Puno sites to 6.2 in New Delhi and Chennai. Self-reported diabetes was lowest in rural Puno (2%) and highest in Dhaka (19.1%). Mean systolic blood pressure was highest in northern China (141 mm Hg), and was lowest in urban Puno (112 mm Hg). Rural Puno reported the lowest proportion of hypertension medication (2%) and northern China reported the highest (25%).

Figure 1 and Supplemental Table 1 report the age-standardized proportion classified as generally obese and centrally obese based on international BMI and waist circumference cutoffs, respectively. For both international and ethnic-specific definitions rural Matlab, Bangladesh, had the lowest proportion of general obesity (2% and 12%, respectively). The highest proportion of obesity varied by definition; under the international classification, Marcos Paz, Argentina, had the highest obesity (44%), and under the ethnic-specific classification, Chennai, India, had the highest obesity (50%). Central obesity was lowest in rural Matlab, Bangladesh (19%), and was highest in Temuco, Chile (79%). In general, the proportion with central obesity was higher than the proportion with general obesity. The proportion of obesity was higher among women compared with men at all sites; in fact, at roughly one-half the sites, the proportion of obese women was near double that of obese men. Supplemental Table 1 shows the proportion underweight, which was lower than the proportion obese in most settings. Obesity by age group, sex, and site is reported in Supplemental Table 2.

Figure 2, top panel, shows the PR of diabetes by site and sex and for the pooled sample among participants aged 40 to 69 years. For every 1 SD higher BMI, we noted a 65% and 60% higher pooled prevalence of diabetes for men and women, respectively (Fig. 2, top left panel). The interaction term between site and BMI was significant among men (p = .008) and women (p < .001), and site-specific PR point estimates ranged from 1.09 to 2.46 among men and 1.20 to 1.91 among women. Every 1 SD higher waist circumference was associated with 48% and 74% higher pooled prevalence of diabetes among men and women, respectively (Fig. 2, top right panel). Associations between waist circumference and diabetes also statistically differed across sites (p = .013 among men and p = .007 among women), and site-specific PR point estimates ranged from 1.17 to 1.93 among men and 1.44 to 2.16 among women.

Figure 1, bottom panel, shows the PRs of hypertension by site and sex and for the pooled sample among participants aged 40 to 69 years. Every 1 SD higher BMI was associated a 42% and 28% higher pooled prevalence of hypertension for men and women, respectively. Associations between BMI and hypertension differed across sites (p < .001 for men and women), and site-specific PR point estimates ranged from 1.09 to 2.21 among men and 1.08 to 1.89 among women. Every 1 SD higher waist circumference was associated with a 34% and 31% higher pooled prevalence of hypertension for women and men. Site-specific PRs for hypertension by SD of waist circumference also varied by site (p = .002 for men and p < .001 for women), with point estimates ranging from 1.10 to 2.21 among men and 1.10 to 2.09 among women.

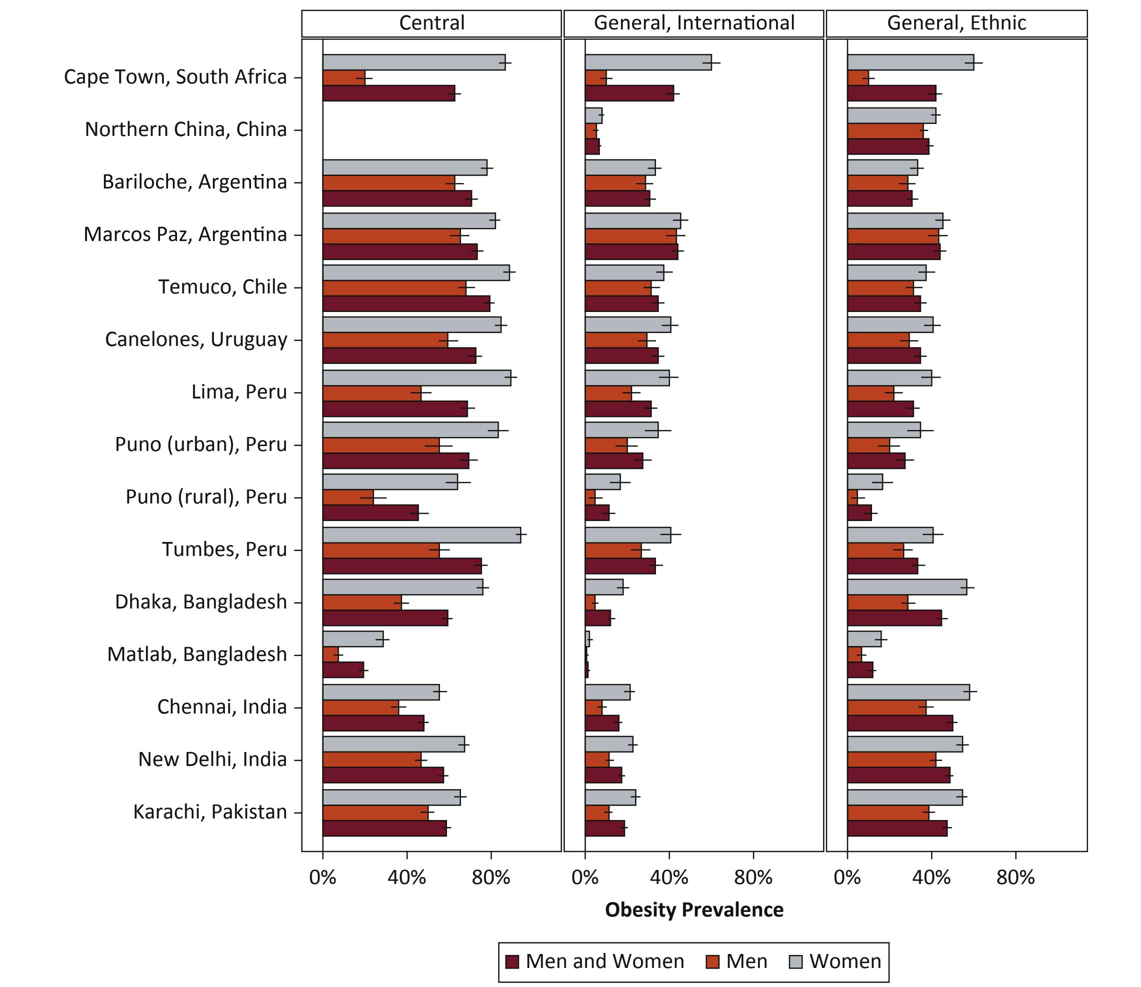

FIGURE 1. Prevalence of central and general obesity by sex. Central obesity is classified based on waist circumference, and general obesity (international and ethnic-specific cutpoints) is classified based on body mass index (BMI). The error bars mark the 95% confidence interval of the prevalence.

Figure 3 shows PRs by region. With the exception of the association between waist circumference and diabetes among men, interactions between obesity measures and region were significant. Both BMI and waist circumference associations with diabetes were highest in South Africa among men and highest in South America among women. Associations of both BMI and waist circumference with hypertension, on the other hand, were lowest in South Africa. Associations with hypertension were relatively similar in East Asia, South America, and South Asia.

Figure 4 reports the sex- and age-stratified associations between BMI and waist circumference exposures with prevalent diabetes and hypertension. With respect to the association between obesity measures and diabetes, we observed that associations were generally strongest in the youngest age group, and remained substantial and significant in older age groups; there was a linear trend by age for BMI and diabetes among men and a linear trend by age for waist circumference and diabetes among women. PR point estimates were higher for women compared with men at ages 20 to 34 years for both obesity measures and diabetes, but did not differ statistically in this or any other age group. Similarly, the associations between both obesity measures were attenuated in older relative to younger age groups, and we observed a significant linear trend in the PR estimates by age in both men and women. BMI—hypertension associations were slightly stronger in men compared with women in each age group; there was no consistent sex difference in associations between waist circumference and hypertension, however.

DISCUSSION

Based on contemporary data collected across geographically and ethnically diverse largely middle-income settings,

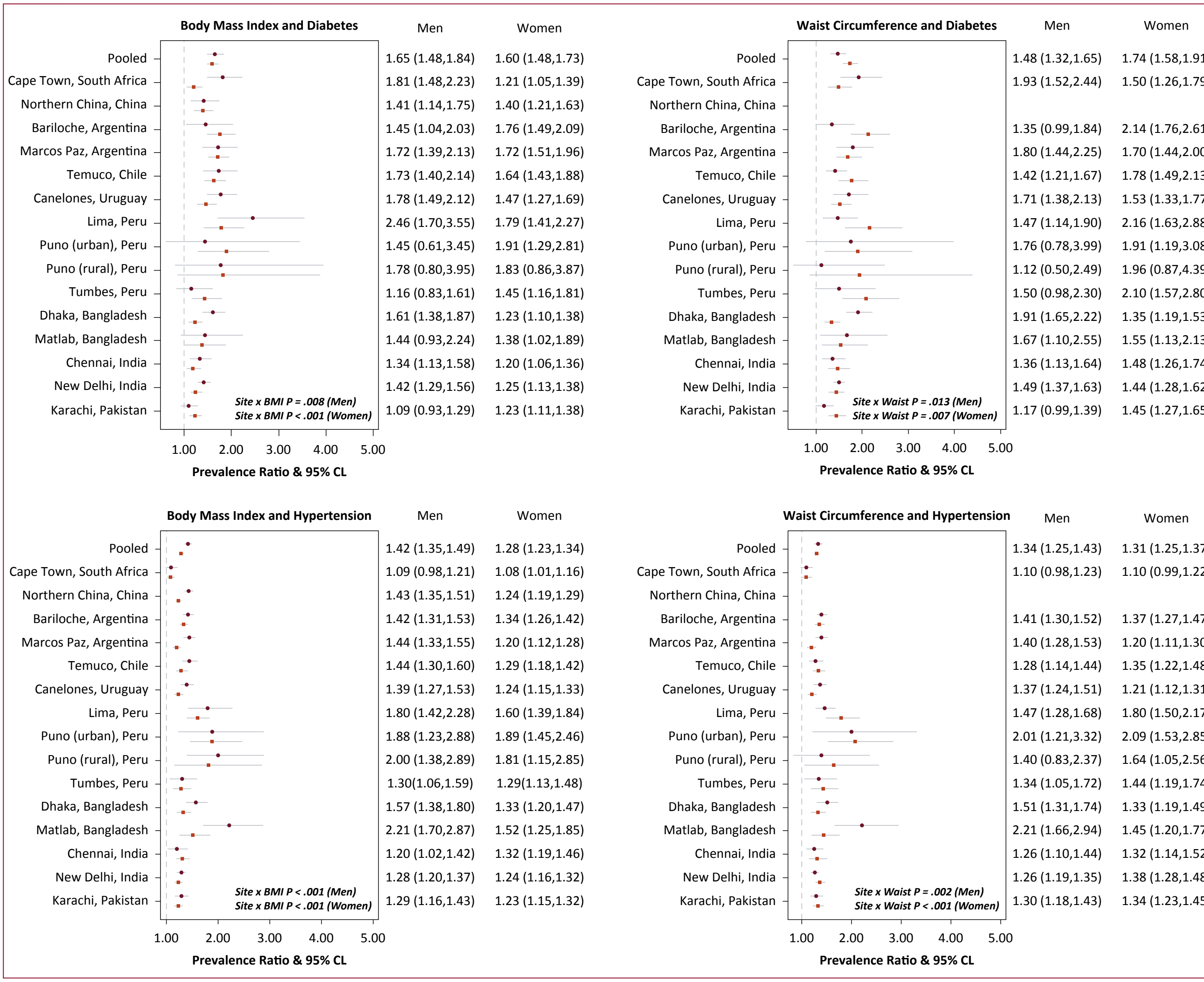

FIGURE 2. Associations between body mass index (BMI) (kg/m^2) (left panels) and waist circumference in (cm) (right panels) and prevalent cardiovascular risk factors among adults aged 40 to 69 years. The circle marks the prevalence ratio estimate for men and the square the estimate for women; the dashed vertical line shows the null value. BMI and waist circumference were standardized to have mean = 0 and SD = 1 to compare.

we examined BMI and waist circumference to assess general and central obesity and investigate their respective associations with diabetes and hypertension. Despite lower BMI in South Asian participants, South Asian cities tended to have the highest proportion of general obesity following ethnic-specific classification, ranging from 45% to 50%. In contrast, central obesity was highest in urban South American sites, ranging from 72% to 79%. At each site, the proportion with central obesity (19% to 79%) was higher than the proportion with general obesity (12% to 50% based on ethnic classifications) with the exception of Chennai, India.

Regarding whether general and central obesity differentially relate to cardiovascular health, we found that the magnitude of pooled PRs for each of diabetes and hypertension did not differ consistently from one another; there was indication that among men BMI had a stronger association with both risk factors and among women that waist circumference may be a stronger correlate of diabetes. Generally, the PRs for diabetes tended to be larger than the PRs for hypertension. Regarding the consistency of associations across sites, obesity measures were positively associated with diabetes and hypertension at all sites (as expected), but PRs did differ statistically by site.

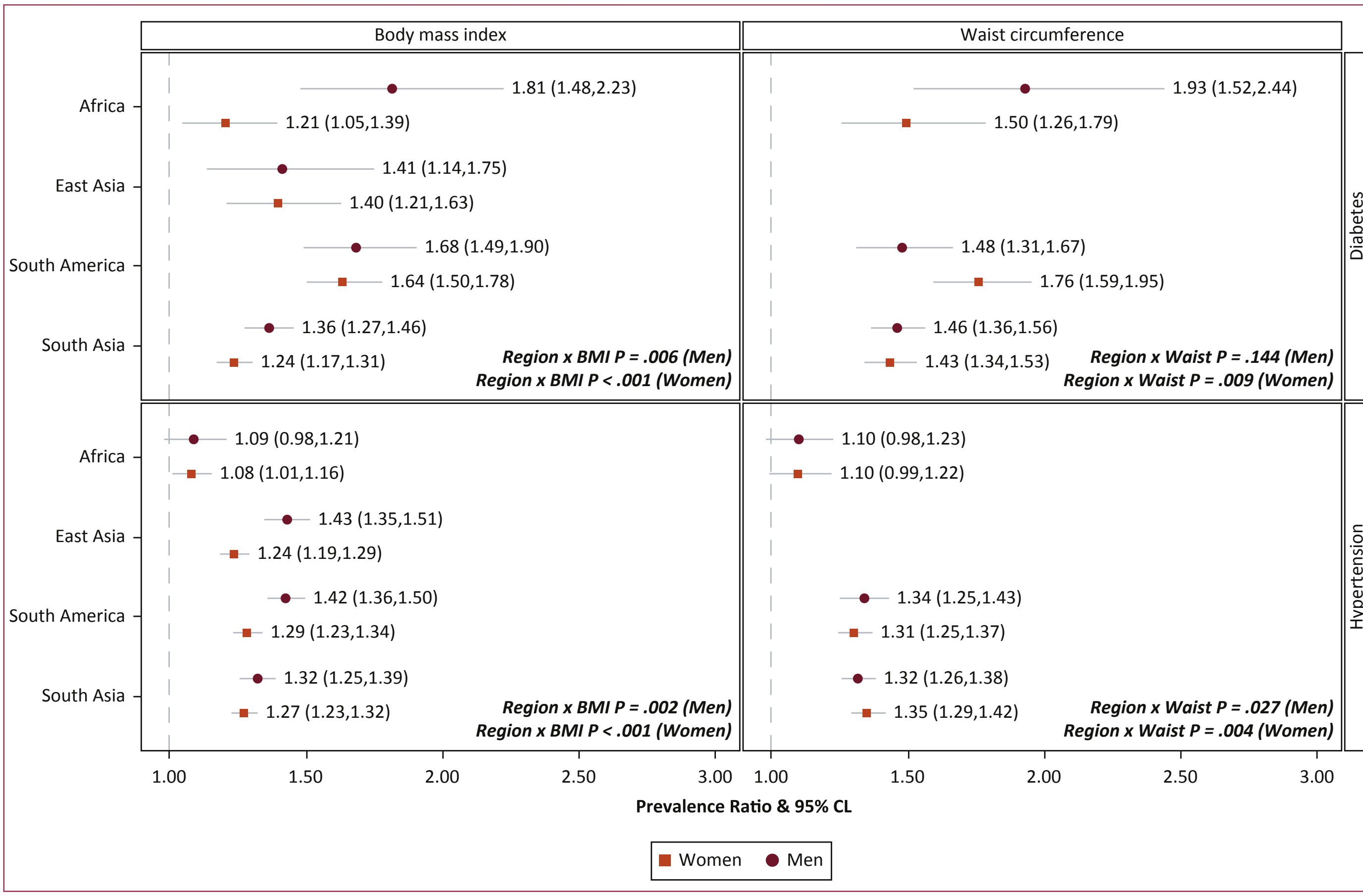

FIGURE 3. Associations of body mass index (BMI) (kg/m^2) and waist circumference (cm) with diabetes and hypertension in each region. The dashed vertical line shows the null value.

The tendency for lower proportions of general obesity in rural locations in East Asia, South Asia, and South America (with the exception of Hebei, China) is consistent with previous studies [27,28]. The fact that the prevalence of general obesity was >10% even in rural settings, however, may reflect the trend of rising obesity observed even in rural areas across MICs [27,29]. Similar to previous studies, we found that associations between obesity measures and cardiovascular health indicators were attenuated with older age. For example, in a large study of Asians and Europeans, the associations between BMI and incident diabetes were higher at younger relative to older ages [30].

Study limitations

The regional variations in obesity associations are intriguing, but must be interpreted cautiously. The studies we drew on were not designed to be representative of their respective nations let alone regions, and further investigation is needed to confirm regional/country patterns we observed. For example, all of Africa was represented by a single study in South Africa. In addition to representing diverse ethnic groups, the studies were situated in varying levels of urbanization, and participants are expected to be socioeconomically diverse. Because the studies were not designed to collect comparable measures of socioeconomic status or contextual factors, we were unable to account statistically for heterogeneity in these factors across sites. Furthermore, the age range of participants differed across studies; this may also contribute to the observed regional variation.

Other limitations of our study include the cross-sectional design, so the direction of observed associations cannot be confirmed. Further, the studies were not intended for all of the subgroup analyses—such as age by sex estimates—which we performed. All the same, we used indirect age standardization to minimize any such differences. We lacked laboratory-assessed fasting plasma glucose to classify undiagnosed diabetes status in China and Bangladesh; measurement error may affect the validity of obesity associations with diabetes in those settings and the comparability of associations with those based on laboratory-assessed fasting plasma glucose. Notwithstanding, a major strength of this study is that Africa and

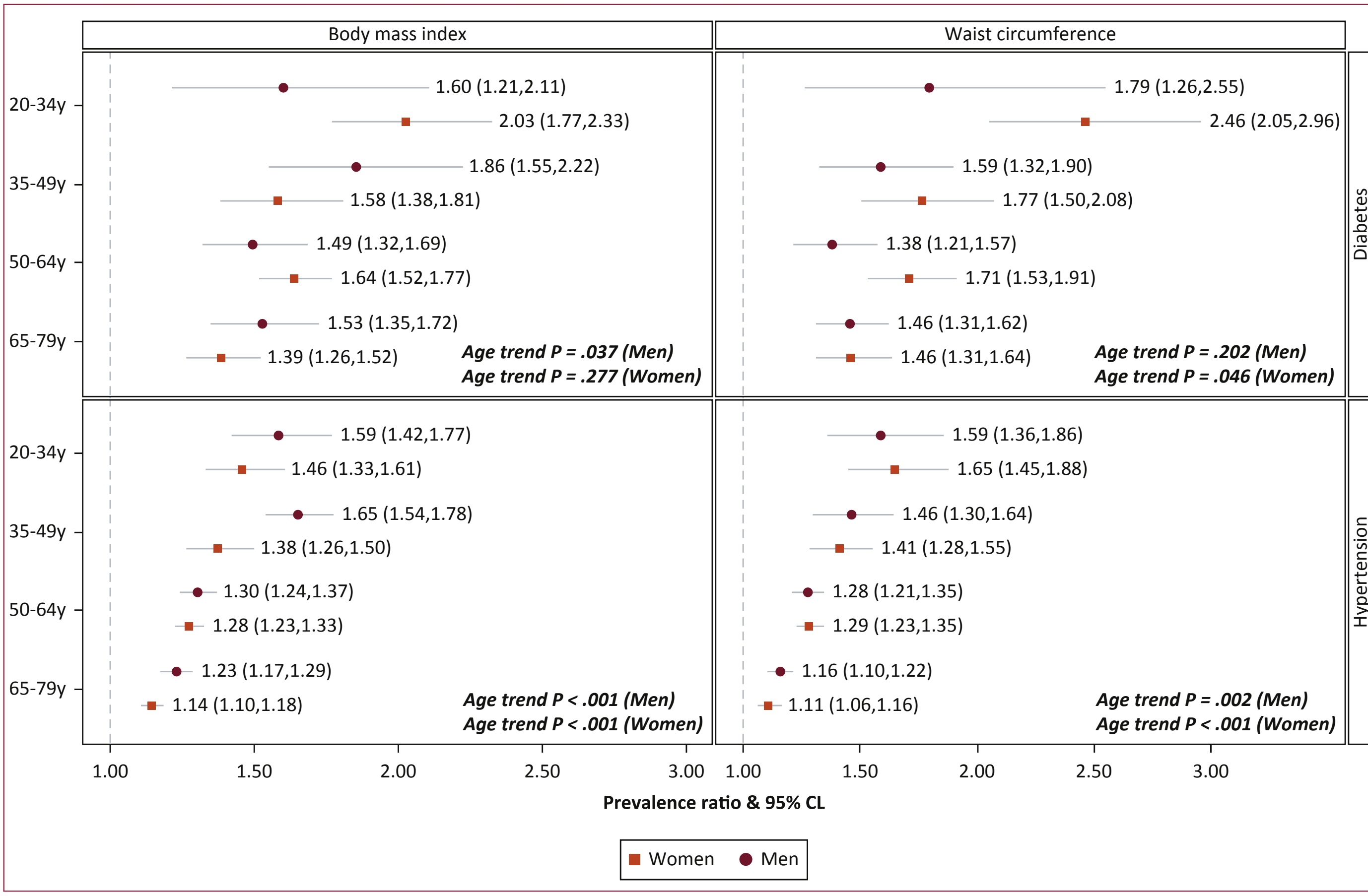

FIGURE 4. Associations of body mass index (BMI) (kg/m^2) and waist circumference (cm) with diabetes and hypertension in each age group. The p value is from the test for a linear trend across age groups. The dashed vertical line shows the null value.

South America data are not often included in multiethnic studies of obesity or its cardiovascular correlates. We also use very recent data to describe obesity, which we know to be a dynamic phenomenon at the population level.

CONCLUSIONS

Although the burden of NCDs is becoming a higher priority for MIC health agendas, it is reasonable to acknowledge that the individual settings are accompanied by nuances and challenges, including different pace of socioeconomic development, urbanization, and social inequalities across regions. Known exposures that contribute to major risk factors and CV outcomes have been well described, yet, our study adds to the literature that the magnitude of associations seems to differ by place [31]. With the recognition that context matters, it is all the more important to question the geographical and temporal stability of apparently established relationships between obesity and cardiovascular health. Our study is well positioned to provide a clear message on this topic, thus contributing information for evidence-based prioritization of policy in a realistic scenario of scarcity of resources. For example, our data suggest that a large fraction of the diabetes burden among men in South Africa and both men and women in South America is related to obesity. Future investigation using these data may quantify burdens of cardiovascular risk factors associated with obesity across these settings.

In conclusion, BMI and waist circumference can provide useful information to classify the presence of hypertension and diabetes in a population. We observed that both obesity measures may have larger magnitudes of associations with diabetes than hypertension and that these associations also tended to be higher in the younger age groups. As contemporary data to investigate obesity and biomarkers of cardiovascular health become increasingly available, additional analyses to answer clinically relevant questions may be undertaken.

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APPENDIX

SUPPLEMENTAL TABLE 1. Prevalence (95% confidence interval) of underweight and obesity*

Region/Site	Underweight	General obesity, international	General obesity, ethnic specific	Central obesity
Men and Women				
Africa				
Cape Town, South Africa	3.9 (2.7,5.1)	41.8 (38.8,44.8)	41.8 (38.8,44.8)	62.4 (59.4,65.4)
East Asia				
Northern China, China	2.8 (2.4,3.3)	6.5 (5.8,7.2)	39.0 (37.6,40.3)	n/a
South America				
Bariloche, Argentina	1.2 (0.6,1.8)	31.0 (28.6,33.3)	31.0 (28.6,33.3)	70.8 (68.3,73.2)
Marcos Paz, Argentina	0.4 (0.1,0.8)	44.2 (41.5,46.9)	44.2 (41.5,46.9)	73.4 (70.8,75.9)
Temuco, Chile	0.2 (0.0,0.4)	34.8 (32.2,37.3)	34.8 (32.2,37.3)	79.1 (76.8,81.3)
Canelones, Uruguay	0.9 (0.4,1.4)	34.9 (32.2,37.6)	34.9 (32.2,37.6)	72.3 (69.6,75.1)
Lima, Peru	0.1 (−0.0,0.3)	31.2 (28.2,34.2)	31.2 (28.2,34.2)	68.8 (65.7,71.8)
Puno (urban), Peru	0.6 (0.1,1.2)	27.4 (23.5,31.4)	27.4 (23.5,31.4)	69.4 (65.3,73.5)
Puno (rural), Peru	1.0 (0.3,1.8)	11.2 (8.4,14.0)	11.2 (8.4,14.0)	45.5 (41.1,49.9)
Tumbes, Peru	0.5 (0.1,0.9)	33.6 (30.5,36.8)	33.6 (30.5,36.8)	75.1 (72.2,78.0)
South Asia				
Dhaka, Bangladesh	10.1 (8.7,11.5)	12.3 (10.8,13.8)	44.8 (42.4,47.1)	59.2 (56.9,61.5)
Matlab, Bangladesh	29.5 (27.3,31.6)	1.7 (1.0,2.3)	11.9 (10.3,13.5)	19.2 (17.3,21.2)
Chennai, India	6.9 (5.8,8.0)	15.9 (14.3,17.6)	49.8 (47.5,52.1)	47.7 (45.4,50.1)
New Delhi, India	9.4 (8.3,10.5)	17.3 (16.0,18.6)	48.4 (46.6,50.2)	57.2 (55.4,59.0)
Karachi, Pakistan	12.5 (11.2,13.8)	18.4 (17.0,19.9)	47.5 (45.6,49.4)	58.6 (56.7,60.5)
Men				
Africa				
Cape Town, South Africa	9.0 (6.0,11.9)	10.0 (7.1,12.9)	10.0 (7.1,12.9)	19.8 (16.0,23.7)
East Asia				
Northern China, China	2.4 (1.8,3.0)	5.2 (4.2,6.1)	36.3 (34.4,38.3)	n/a
South America				
Bariloche, Argentina	0.6 (−0.1,1.4)	28.6 (25.0,32.3)	28.6 (25.0,32.3)	62.9 (58.8,66.9)
Marcos Paz, Argentina	0.0 (0.0,0.0)	43.1 (38.7,47.5)	43.1 (38.7,47.5)	65.2 (60.9,69.5)
Temuco, Chile	0.2 (−0.1,0.4)	31.4 (27.8,35.1)	31.4 (27.8,35.1)	68.1 (64.4,71.8)
Canelones, Uruguay	0.5 (0.1,1.0)	29.2 (25.2,33.3)	29.2 (25.2,33.3)	59.6 (55.1,64.1)
Lima, Peru	0.1 (−0.1,0.2)	22.1 (18.2,25.9)	22.1 (18.2,25.9)	46.9 (42.3,51.6)
Puno (urban), Peru	0.3 (−0.3,0.9)	19.7 (14.6,24.8)	19.7 (14.6,24.8)	55.0 (48.7,61.4)
Puno (rural), Peru	1.4 (−0.0,2.8)	4.9 (2.1,7.8)	4.9 (2.1,7.8)	24.0 (18.3,29.7)
Tumbes, Peru	0.5 (0.0,1.0)	26.5 (22.3,30.8)	26.5 (22.3,30.8)	55.5 (50.8,60.3)
South Asia				
Dhaka, Bangladesh	14.6 (12.2,17.0)	4.9 (3.4,6.3)	29.0 (25.8,32.2)	37.4 (34.1,40.8)
Matlab, Bangladesh	36.2 (32.8,39.7)	0.8 (0.1,1.4)	6.6 (4.8,8.4)	7.2 (5.4,9.1)
Chennai, India	8.8 (6.9,10.7)	8.1 (6.2,10.1)	37.2 (33.7,40.7)	35.9 (32.4,39.3)
New Delhi, India	10.3 (8.7,12.0)	11.7 (10.1,13.3)	41.8 (39.3,44.3)	46.7 (44.1,49.2)
Karachi, Pakistan	14.3 (12.3,16.4)	11.1 (9.4,12.9)	38.6 (35.8,41.3)	49.8 (47.0,52.7)
Women				
Africa				
Cape Town, South Africa	1.0 (0.2,1.8)	60.0 (56.2,63.8)	60.0 (56.2,63.8)	86.8 (84.1,89.5)
East Asia				
Northern China, China	3.2 (2.6,3.9)	7.9 (6.9,9.0)	41.8 (39.8,43.7)	n/a
South America				
Bariloche, Argentina	1.7 (0.8,2.7)	33.1 (30.0,36.2)	33.1 (30.0,36.2)	78.0 (75.2,80.8)
Marcos Paz, Argentina	0.9 (0.2,1.5)	45.3 (42.0,48.5)	45.3 (42.0,48.5)	81.6 (79.0,84.3)

(continued)

SUPPLEMENTAL TABLE 1–*continued*. Prevalence (95% confidence interval) of underweight and obesity*

Region/Site	Underweight	General obesity, international	General obesity, ethnic specific	Central obesity
Temuco, Chile	0.3 (0.0,0.6)	37.7 (34.1,41.2)	37.7 (34.1,41.2)	88.6 (86.2,91.0)
Canelones, Uruguay	1.2 (0.4,2.1)	40.3 (36.7,44.0)	40.3 (36.7,44.0)	84.7 (81.7,87.6)
Lima, Peru	0.2 (−0.1,0.4)	39.7 (35.3,44.1)	39.7 (35.3,44.1)	89.2 (86.4,92.1)
Puno (urban), Peru	1.0 (−0.0,1.9)	34.8 (28.9,40.7)	34.8 (28.9,40.7)	83.1 (78.4,87.7)
Puno (rural), Peru	0.7 (−0.0,1.5)	16.6 (12.0,21.2)	16.6 (12.0,21.2)	64.2 (58.5,69.9)
Tumbes, Peru	0.4 (−0.2,1.1)	40.5 (35.9,45.1)	40.5 (35.9,45.1)	94.1 (91.8,96.3)
South Asia				
Dhaka, Bangladesh	6.7 (5.2,8.2)	18.0 (15.6,20.4)	56.8 (53.7,59.9)	75.9 (73.2,78.6)
Matlab, Bangladesh	24.2 (21.5,26.9)	2.4 (1.4,3.4)	15.9 (13.5,18.4)	28.5 (25.6,31.5)
Chennai, India	5.6 (4.3,7.0)	21.1 (18.7,23.5)	58.1 (55.1,61.0)	55.6 (52.6,58.6)
New Delhi, India	8.6 (7.0,10.1)	22.5 (20.5,24.6)	54.6 (52.1,57.1)	67.1 (64.6,69.5)
Karachi, Pakistan	11.0 (9.4,12.7)	24.0 (21.9,26.2)	54.4 (51.9,56.9)	65.4 (62.9,67.8)

*General obesity is classified based on body mass index and central obesity is classified based on waist circumference.
n/a, not applicable.

SUPPLEMENTAL TABLE 2. Obesity* prevalence (95% confidence interval) by site, age, and sex

Region/Site	Age group (yrs)	No. of men and women	Men and Women			Men			Women		
			General obesity, international	General obesity, ethnic specific	Central obesity	General obesity, international	General obesity, ethnic specific	Central obesity	General obesity, international	General obesity, ethnic specific	Central obesity
Africa											
Cape Town, South Africa	20-34	360	36.0 (31.1,41.0)	36.0 (31.1,41.0)	54.9 (49.7,60.0)	4.8 (1.1,8.6)	4.8 (1.1,8.6)	9.5 (4.4,14.7)	52.5 (46.1,58.9)	52.5 (46.1,58.9)	78.8 (73.5,84.0)
	35-49	384	43.3 (38.4,48.3)	43.3 (38.4,48.3)	64.5 (59.7,69.3)	9.0 (4.3,13.6)	9.0 (4.3,13.6)	19.0 (12.6,25.4)	64.4 (58.3,70.5)	64.4 (58.3,70.5)	92.4 (89.0,95.8)
	50-64	259	49.7 (43.6,55.9)	49.7 (43.6,55.9)	73.2 (67.8,78.7)	21.1 (12.8,29.4)	21.1 (12.8,29.4)	38.5 (28.7,48.3)	66.7 (59.4,74.0)	66.7 (59.4,74.0)	93.8 (90.1,97.6)
	65-79	85	54.6 (43.8,65.4)	54.6 (43.8,65.4)	75.2 (65.9,84.6)	22.2 (8.2,36.2)	22.2 (8.2,36.2)	48.1 (30.5,65.8)	73.8 (62.0,85.5)	73.8 (62.0,85.5)	91.2 (83.7,98.8)
East Asia											
Northern China, China	20-34	295	5.3 (2.8,7.9)	28.9 (23.8,34.1)	n/a	5.6 (1.8,9.3)	34.7 (26.9,42.6)	n/a	5.1 (1.6,8.5)	23.7 (17.0,30.3)	n/a
	35-49	496	6.9 (4.7,9.1)	41.4 (37.0,45.7)	n/a	6.5 (3.4,9.5)	44.0 (37.8,50.2)	n/a	7.3 (4.1,10.6)	38.7 (32.6,44.8)	n/a
	50-64	2615	7.0 (6.0,8.0)	40.4 (38.5,42.3)	n/a	5.5 (4.3,6.7)	35.9 (33.4,38.4)	n/a	9.3 (7.6,11.0)	47.2 (44.2,50.1)	n/a
	65-79	2260	5.8 (4.8,6.9)	38.9 (36.8,41.0)	n/a	2.7 (1.6,3.9)	32.1 (28.8,35.5)	n/a	7.6 (6.2,9.0)	42.6 (40.0,45.2)	n/a
South America											
Bariloche, Argentina	35-49	712	27.5 (24.1,31.0)	27.5 (24.1,31.0)	67.4 (63.7,71.0)	25.6 (20.4,30.8)	25.6 (20.4,30.8)	59.4 (53.4,65.3)	29.4 (25.0,33.9)	29.4 (25.0,33.9)	75.0 (70.7,79.2)
	50-64	918	35.4 (32.1,38.7)	35.4 (32.1,38.7)	75.1 (72.0,78.2)	33.7 (28.6,38.8)	33.7 (28.6,38.8)	67.9 (62.7,73.0)	37.0 (32.9,41.2)	37.0 (32.9,41.2)	81.8 (78.4,85.1)
	65-79	351	39.0 (33.9,44.2)	39.0 (33.9,44.2)	79.8 (75.5,84.1)	32.8 (25.1,40.6)	32.8 (25.1,40.6)	71.7 (64.3,79.1)	43.8 (37.0,50.7)	43.8 (37.0,50.7)	86.1 (81.2,90.9)
Marcos Paz, Argentina	35-49	718	42.1 (38.2,46.0)	42.1 (38.2,46.0)	70.7 (66.9,74.4)	43.2 (37.0,49.5)	43.2 (37.0,49.5)	63.0 (56.9,69.1)	40.9 (36.3,45.6)	40.9 (36.3,45.6)	78.9 (75.0,82.8)
	50-64	833	47.8 (44.2,51.4)	47.8 (44.2,51.4)	76.2 (73.0,79.4)	42.7 (37.2,48.3)	42.7 (37.2,48.3)	66.7 (61.3,72.0)	52.5 (47.9,57.1)	52.5 (47.9,57.1)	85.1 (81.8,88.4)
	65-79	420	46.8 (42.0,51.6)	46.8 (42.0,51.6)	87.0 (83.7,90.3)	40.6 (33.2,48.0)	40.6 (33.2,48.0)	80.7 (74.8,86.6)	52.1 (45.8,58.4)	52.1 (45.8,58.4)	92.4 (89.1,95.8)
Temuco, Chile	35-49	746	33.2 (29.7,36.7)	33.2 (29.7,36.7)	77.3 (74.2,80.4)	30.3 (25.4,35.2)	30.3 (25.4,35.2)	66.8 (61.7,71.8)	35.9 (30.9,40.9)	35.9 (30.9,40.9)	87.2 (83.7,90.7)
	50-64	739	36.1 (32.5,39.8)	36.1 (32.5,39.8)	81.4 (78.5,84.4)	32.6 (27.3,37.8)	32.6 (27.3,37.8)	69.7 (64.5,74.9)	38.9 (33.9,43.9)	38.9 (33.9,43.9)	90.4 (87.3,93.5)
	65-79	449	39.1 (34.5,43.7)	39.1 (34.5,43.7)	83.6 (80.2,87.0)	32.2 (25.8,38.6)	32.2 (25.8,38.6)	71.8 (65.7,77.9)	44.2 (37.8,50.6)	44.2 (37.8,50.6)	92.3 (88.8,95.7)
Canelones, Uruguay	35-49	531	29.4 (25.5,33.3)	29.4 (25.5,33.3)	66.8 (62.6,71.0)	25.8 (20.1,31.4)	25.8 (20.1,31.4)	53.7 (47.2,60.2)	33.3 (27.9,38.7)	33.3 (27.9,38.7)	80.9 (76.2,85.5)
	50-64	637	43.1 (39.0,47.2)	43.1 (39.0,47.2)	79.4 (75.9,82.8)	36.3 (30.0,42.6)	36.3 (30.0,42.6)	67.4 (61.3,73.5)	49.0 (43.8,54.2)	49.0 (43.8,54.2)	89.6 (86.3,93.0)
	65-79	389	42.2 (37.2,47.2)	42.2 (37.2,47.2)	84.8 (81.1,88.5)	28.4 (21.2,35.5)	28.4 (21.2,35.5)	75.5 (68.7,82.3)	53.4 (46.9,59.9)	53.4 (46.9,59.9)	92.3 (88.7,95.8)
Lima, Peru	35-49	378	27.8 (23.3,32.3)	27.8 (23.3,32.3)	63.9 (59.0,68.8)	17.8 (12.3,23.4)	17.8 (12.3,23.4)	40.0 (32.9,47.1)	37.3 (30.5,44.1)	37.3 (30.5,44.1)	86.8 (82.0,91.6)
	50-64	403	34.6 (29.9,39.3)	34.6 (29.9,39.3)	75.3 (71.0,79.5)	26.5 (20.2,32.8)	26.5 (20.2,32.8)	54.9 (47.8,62.0)	42.0 (35.2,48.7)	42.0 (35.2,48.7)	93.9 (90.6,97.3)
	65-79	237	34.6 (28.3,40.9)	34.6 (28.3,40.9)	68.5 (62.5,74.5)	26.2 (17.8,34.5)	26.2 (17.8,34.5)	51.5 (42.2,60.9)	42.4 (33.3,51.4)	42.4 (33.3,51.4)	84.3 (77.8,90.8)
Puno (urban), Peru	35-49	203	25.3 (19.3,31.2)	25.3 (19.3,31.2)	67.7 (61.2,74.2)	20.0 (12.1,27.9)	20.0 (12.1,27.9)	52.2 (42.3,62.1)	30.3 (21.5,39.1)	30.3 (21.5,39.1)	82.6 (75.3,89.9)
	50-64	212	31.9 (25.5,38.2)	31.9 (25.5,38.2)	71.6 (65.4,77.7)	20.5 (12.6,28.4)	20.5 (12.6,28.4)	56.0 (46.3,65.7)	42.7 (33.3,52.1)	42.7 (33.3,52.1)	86.4 (79.9,92.9)
	65-79	131	23.2 (15.8,30.6)	23.2 (15.8,30.6)	69.8 (61.8,77.8)	16.0 (6.6,25.3)	16.0 (6.6,25.3)	64.2 (52.2,76.2)	29.9 (18.8,41.0)	29.9 (18.8,41.0)	75.1 (64.5,85.6)
Puno (rural), Peru	35-49	194	12.2 (7.6,16.8)	12.2 (7.6,16.8)	51.7 (44.6,58.7)	5.4 (0.8,9.9)	5.4 (0.8,9.9)	28.3 (19.1,37.5)	18.4 (10.9,26.0)	18.4 (10.9,26.0)	72.9 (64.3,81.5)
	50-64	224	11.6 (7.4,15.8)	11.6 (7.4,15.8)	42.5 (36.0,49.0)	5.1 (0.7,9.4)	5.1 (0.7,9.4)	22.5 (14.1,30.8)	16.8 (10.2,23.4)	16.8 (10.2,23.4)	58.3 (49.6,67.1)
	65-79	136	5.6 (1.5,9.8)	5.6 (1.5,9.8)	30.4 (22.3,38.5)	2.9 (−1.2,7.0)	2.9 (−1.2,7.0)	11.9 (3.9,20.0)	8.4 (1.3,15.4)	8.4 (1.3,15.4)	48.5 (36.2,60.8)

Tumbes, Peru	35-49	381	32.5 (27.8,37.2)	32.5 (27.8,37.2)	71.7 (67.1,76.2)	25.6 (19.4,31.7)	25.6 (19.4,31.7)	50.2 (43.1,57.3)	39.6 (32.6,46.6)	39.6 (32.6,46.6)	93.6 (90.0,97.1)
	50-64	379	38.4 (33.5,43.4)	38.4 (33.5,43.4)	80.2 (76.2,84.2)	30.9 (24.1,37.8)	30.9 (24.1,37.8)	63.7 (56.6,70.8)	45.2 (38.2,52.1)	45.2 (38.2,52.1)	94.9 (91.8,98.0)
	65-79	213	22.8 (17.0,28.5)	22.8 (17.0,28.5)	75.0 (69.0,81.0)	17.0 (9.6,24.4)	17.0 (9.6,24.4)	55.8 (46.1,65.6)	28.3 (19.6,37.0)	28.3 (19.6,37.0)	93.5 (88.4,98.6)
South Asia											
Dhaka, Bangladesh	35-49	906	13.5 (11.3,15.7)	48.9 (45.6,52.2)	61.1 (57.9,64.2)	4.7 (2.5,7.0)	31.3 (26.3,36.2)	34.9 (29.8,39.9)	18.8 (15.6,22.1)	59.6 (55.5,63.6)	76.9 (73.4,80.4)
	50-64	761	11.0 (8.7,13.2)	39.6 (36.0,43.1)	57.0 (53.4,60.6)	4.7 (2.6,6.8)	25.4 (21.0,29.7)	39.2 (34.3,44.1)	17.3 (13.4,21.2)	54.0 (48.9,59.2)	75.1 (70.7,79.6)
	65-79	215	8.4 (4.6,12.3)	35.6 (29.0,42.2)	54.5 (47.7,61.3)	6.8 (2.1,11.5)	34.4 (25.7,43.1)	44.8 (35.7,53.9)	10.5 (4.2,16.9)	37.1 (27.1,47.1)	66.9 (57.2,76.5)
Matlab, Bangladesh	35-49	682	2.2 (1.1,3.3)	13.9 (11.3,16.5)	19.8 (16.8,22.8)	1.1 (−0.1,2.4)	7.3 (4.2,10.4)	6.5 (3.6,9.5)	2.9 (1.3,4.6)	18.3 (14.5,22.1)	28.8 (24.4,33.2)
	50-64	771	1.1 (0.3,1.9)	10.8 (8.6,13.1)	19.9 (17.0,22.8)	0.6 (−0.2,1.4)	6.9 (4.2,9.6)	7.9 (5.1,10.7)	1.5 (0.3,2.7)	14.0 (10.6,17.4)	29.8 (25.4,34.3)
	65-79	352	1.3 (0.0,2.6)	6.4 (3.7,9.1)	13.2 (9.5,16.9)	0.0 (0.0,0.0)	2.8 (0.5,5.1)	7.6 (3.7,11.4)	2.8 (0.1,5.6)	10.6 (5.5,15.6)	19.8 (13.3,26.3)
Chennai, India	20-34	1078	15.3 (12.4,18.2)	45.7 (41.8,49.5)	41.4 (37.5,45.2)	8.0 (4.2,11.9)	31.0 (25.3,36.8)	27.7 (22.1,33.3)	19.4 (15.5,23.4)	54.0 (49.1,58.8)	49.2 (44.3,54.0)
	35-49	1448	16.2 (13.8,18.6)	54.9 (51.5,58.4)	51.3 (47.8,54.8)	8.7 (5.9,11.4)	44.0 (38.6,49.4)	40.2 (34.9,45.5)	21.4 (17.9,24.9)	62.3 (57.9,66.8)	58.9 (54.3,63.4)
	50-64	649	16.7 (12.7,20.7)	47.9 (42.5,53.2)	53.8 (48.4,59.1)	6.0 (2.8,9.2)	34.4 (26.8,41.9)	41.8 (33.9,49.6)	25.6 (19.1,32.0)	59.1 (51.9,66.4)	63.7 (56.6,70.9)
	65-79	173	17.4 (7.9,27.0)	34.0 (23.4,44.6)	51.9 (40.9,62.9)	14.1 (0.7,27.5)	26.0 (12.3,39.7)	37.5 (23.1,52.0)	21.0 (7.3,34.7)	42.8 (26.7,58.9)	67.6 (52.9,82.3)
New Delhi, India	20-34	863	8.2 (6.2,10.2)	33.5 (30.0,37.0)	36.7 (33.2,40.3)	5.3 (3.0,7.6)	31.3 (26.3,36.4)	26.3 (21.5,31.0)	10.6 (7.5,13.7)	35.2 (30.4,40.0)	45.2 (40.2,50.1)
	35-49	1691	19.9 (17.8,21.9)	53.7 (51.1,56.3)	63.0 (60.5,65.6)	13.0 (10.5,15.5)	44.2 (40.4,47.9)	50.9 (47.1,54.7)	26.3 (23.1,29.4)	62.5 (59.0,66.0)	74.3 (71.1,77.5)
	50-64	988	24.5 (21.7,27.4)	58.4 (55.0,61.8)	72.5 (69.4,75.5)	16.6 (13.3,20.0)	50.7 (45.9,55.5)	62.1 (57.4,66.7)	33.1 (28.6,37.6)	66.7 (62.0,71.4)	83.7 (80.2,87.3)
	65-79	331	19.6 (14.7,24.4)	49.2 (43.1,55.3)	68.3 (62.6,74.0)	14.6 (8.6,20.7)	39.9 (31.9,47.8)	55.5 (47.4,63.6)	26.6 (18.7,34.6)	62.4 (53.4,71.5)	86.6 (80.8,92.5)
Karachi, Pakistan	20-34	989	11.5 (9.5,13.5)	31.7 (28.7,34.6)	37.2 (34.2,40.3)	7.4 (4.9,9.8)	25.1 (20.9,29.3)	28.2 (23.8,32.5)	14.7 (11.7,17.7)	36.9 (32.8,41.0)	44.4 (40.2,48.6)
	35-49	1199	24.1 (21.6,26.6)	60.0 (57.2,62.8)	72.5 (69.9,75.1)	14.6 (11.3,17.9)	49.8 (45.2,54.5)	63.7 (59.3,68.2)	30.1 (26.7,33.5)	66.4 (62.9,69.9)	78.0 (75.0,81.0)
	50-64	592	21.9 (18.5,25.4)	56.8 (52.7,60.9)	77.0 (73.5,80.5)	12.4 (8.6,16.2)	47.1 (41.3,52.9)	70.0 (64.7,75.3)	31.5 (26.0,37.0)	66.5 (60.9,72.1)	84.1 (79.7,88.4)
	65-79	189	15.8 (10.1,21.4)	43.3 (35.9,50.7)	65.9 (58.9,72.8)	12.1 (6.0,18.2)	37.5 (28.9,46.1)	58.3 (49.7,66.9)	25.1 (12.7,37.5)	58.2 (44.7,71.7)	85.3 (76.1,94.5)

*General obesity (international and ethnic-specific cutpoints) is classified based on body mass index and central obesity is classified based on waist circumference.
n/a, not applicable.