

# Prevalence of overweight and obesity and their association with hypertension and diabetes mellitus in an Indo-Asian population

Tazeen H. Jafar, Nish Chaturvedi, Gregory Pappas

∞ See related article page 1081

## ABSTRACT

**Background:** The associations of body mass index (BMI) and chronic disease may differ between Indo-Asian and Western populations. We used Indo-Asian-specific definitions of overweight and obesity to determine the prevalence of these problems in Pakistan and studied the sensitivity and specificity of BMI cutoff values for an association with hypertension and diabetes mellitus.

**Methods:** We analyzed data for 8972 people aged 15 years or more from the National Health Survey of Pakistan (1990–1994). People considered overweight or obese were those with a BMI of 23 kg/m<sup>2</sup> or greater, and those considered obese as having a BMI of 27 kg/m<sup>2</sup> or greater. We built multivariable models and performed logistic regression analysis.

**Results:** The prevalence of overweight and obesity, weighted to the general Pakistani population, was 25.0% (95% confidence interval [CI] 21.8%–28.2%). The prevalence of obesity was 10.3% (95% CI 7.0%–13.2%). The factors independently and significantly associated with overweight and obesity included greater age, being female, urban residence, being literate, and having a high (v. low) economic status and a high (v. low) intake of meat. With receiver operating characteristic curves, we found that the use of even lower BMI cutoff values (21.2 and 22.1 kg/m<sup>2</sup> for men and 21.2 and 22.9 kg/m<sup>2</sup> for women) than those recommended for an Indo-Asian population yielded the optimal areas under the curve for an association with hypertension and diabetes, respectively.

**Interpretation:** A quarter of the population of Pakistan would be classified as overweight or obese with the use of Indo-Asian-specific BMI cutoff values. Optimal identification of those at risk of hypertension and diabetes and healthy targets may require the use of even lower BMI cutoff values than those already proposed for an Indo-Asian population.

CMAJ 2006;175(9):1071-7

DOI:10.1503/cmaj.060464

Developing countries are increasingly vulnerable to the worldwide epidemic of obesity, which affects all segments of the population, including men, women and now children.<sup>1,2</sup> Compared with populations in industri-

alized countries, those in the developing world appear to be at greater risk of the diseases associated with overweight, and cardiovascular disease has become the leading cause of disability and death in many developing countries.<sup>3–5</sup>

Worldwide, Indo-Asian people are among the populations at highest risk for cardiovascular disease.<sup>6</sup> Evidence also suggests that associations between body mass index (BMI), percentage of body fat and chronic disease may differ between Indo-Asian and European populations.<sup>7,8</sup> One proposed explanation for these observations is the effect of poverty and resultant malnutrition during intrauterine and early childhood years, coupled with relative overnutrition in later years.<sup>9</sup> There may, however, be other factors at work. Because of the observed differences between populations, the International Association for the Study of Obesity and the International Obesity Task Force have suggested lower BMI cutoff values for the definitions of overweight (23.0–24.9 kg/m<sup>2</sup>) and obesity (25.0 kg/m<sup>2</sup> or greater) in Asian populations.<sup>10,11</sup> Estimates of the prevalence of overweight in Indo-Asian countries (India, Pakistan, Bangladesh and Sri Lanka) based on these cutoff values have not been reported. Further, it is not known whether the revised definition of overweight would be valid at a population level in terms of being better associated with the consequences of obesity.

We therefore sought to determine the prevalence of overweight and obesity using the Asian-specific BMI definition in a Pakistani population. We also studied factors and conditions (hypertension, diabetes mellitus and raised serum cholesterol concentration) associated with being overweight or obese in the Pakistani population, as well as the sensitivity and specificity of various BMI cutoff values for their association with hypertension and diabetes mellitus.

## Methods

The analysis was based on cross-sectional data collected in the 1990–1994 National Health Survey of Pakistan, conducted by the Pakistan Medical Research Council, under the technical guidance and support of the US National Center for Health Statistics. The overall design of the survey was a modification of the Third National Health and Nutrition Examination Survey (NHANES III), conducted by the US National Cen-

**Table 1:** Age-specific prevalence of overweight and obesity\* in Pakistan

Age, yr	Overweight or obese women		Overweight or obese men	
	No.	% (95% CI)†	No.	% (95% CI)†
15-24	195/1373	13.8 (10.5-17.1)	179/1352	12.4 (9.0-15.8)
25-34	263/983	26.3 (21.6-31.0)	225/904	24.1 (19.3-28.9)
35-44	340/777	42.8 (37.1-48.5)	231/712	31.4 (26.8-36.0)
45-54	263/623	41.3 (35.4-47.2)	161/559	28.2 (22.6-33.8)
55-64	140/444	33.0 (27.6-38.4)	114/427	24.9 (20.1-29.7)
≥ 65	95/358	25.1 (19.5-30.7)	109/460	21.4 (17.7-25.1)
All	1296/4558	28.2 (24.7-31.7)	1019/4414	22.0 (18.9-25.2)

Note: CI = confidence interval.

\*The category of overweight and obesity was defined as a body mass index (BMI)  $\geq 23$  kg/m<sup>2</sup>.

†Weighted to the general Pakistani population.

ter for Health Statistics, tailored to the needs of Pakistan. The details of sampling, design, components, survey instruments and quality control have previously been reported.<sup>12</sup> Ethical approval for the survey was obtained from the Institutional Review Board at the Pakistan Medical Research Council.<sup>13</sup>

In brief, the survey was conducted on a nationally representative sample of 18 135 people aged 6 months to 110 years from 2400 urban and rural households who gave informed consent. A 2-stage stratified design was used.<sup>14</sup> The urban and rural areas of each of the 4 provinces of Pakistan were taken as strata. There were 80 urban or rural primary sampling units; 30 households were drawn into the sample from each unit, and all residents of the household were included in the study. The overall individual response rate was 92.6%.

Data on demographic, socioeconomic and health-related variables were collected with a questionnaire validated in local languages. Dietary data were collected with a food-frequency questionnaire. All women aged 40 years or under were asked whether they were currently pregnant. Physicians at mobile examination centres performed a standardized physical examination that included 2 blood pressure readings obtained at least 20 minutes apart from the right arm by means of a mercury sphygmomanometer with the subject sitting. Trained technicians performed anthropometric examinations. Weight and height were recorded while the subject was in light clothing and without shoes. BMI was calculated as weight (in kilograms) divided by height (in metres) squared. Blood samples were obtained at least 1 hour after the subject arrived at the examination centre; fasting was not required. Blood glucose and serum cholesterol concentrations were determined with the use of the Reflotron, a multiphasic biochemical analyzer.<sup>15</sup> Random midstream urine samples were tested with Multistix 10 SG urinalysis strips (Bayer HealthCare, Diagnostics Division, Tarrytown, NY; reagent, tetrabromophenol blue) in subjects aged 5 years or over. Quality-control measures included a field visit by expert consultants, duplicate examination by field supervisors, calibration protocols and retraining exercises.<sup>16</sup>

The category of overweight and obesity was defined as a BMI of 23 kg/m<sup>2</sup> or greater. This definition, based on the re-

vised criteria for Asian populations,<sup>11</sup> was lower than the conventional cutoff value of 25 kg/m<sup>2</sup> for populations of European origin and reflects the higher ratio of body fat to muscle mass in the former. Obesity was defined as a BMI of 27 kg/m<sup>2</sup> or greater.

Ethnicity was reported as "mother tongue," which is specific for each of the 5 major ethnic subgroups of Pakistan: Muhajir, Punjabi, Baluch, Sindhi and Pashtun. Literacy was defined as whether an individual could read or not. Three levels of economic status were defined by simply counting owned items with use of a list of household electrical items and owned transport vehicles; this measure has been validated.<sup>17</sup> High intake of meat, fruit, milk, eggs, rice and potatoes was defined as consumption of these items at least every other day. Use of

tobacco (cigarettes, "beddies" [hand-rolled, often filterless cigarettes wrapped in temburni leaf or tendu leaf that are available in a variety of candy-like flavours], and chewing tobacco or snuff) was dichotomized as current use or not. Hypertension was defined as a systolic blood pressure of 140 mm Hg or greater or a diastolic blood pressure of 90 mm Hg or greater (based on the mean of the 2 readings) or current therapy with antihypertensive medication. Diabetes was defined as a nonfasting blood glucose concentration of 140 mg/dL (7.8 mmol/L) or greater or a history of diabetes; this definition, based on old criteria,<sup>18</sup> diverges from the recent standard criterion of a fasting blood glucose concentration of more than 126 mg/dL (7.0 mmol/L).<sup>19</sup> Proteinuria was defined as a urine protein concentration of 30 mg/dL (0.3 g/L) or greater as measured by a reagent strip (reading of 1+ or greater).<sup>20</sup>

Prevalence and 95% confidence intervals (CIs) were calculated with weighting that reflected the oversampling of urban areas and the 3 smaller provinces. Multivariable models were built for the primary outcome of overweight. The candidate predictor list included sociodemographic variables (age, sex, urban v. rural dwelling, literacy status, economic status, high intake of meat, fruit, milk, eggs, rice and potatoes, and current cigarette use). Variables associated with the primary outcome with  $p < 0.1$  in the stepwise multiple regression analysis were considered for selection in the multivariable model.

**Table 2:** Prevalence of overweight and obesity in the surveyed Pakistani population aged 15 years or more according to various BMI cutoff values

BMI, kg/m <sup>2</sup>	Proportion overweight or obese, % (95% CI)		
	All	Women	Men
≥ 23	25.0 (21.8-28.2)	27.9 (24.4-31.4)	22.0 (18.5-25.5)
≥ 25	15.7 (12.9-18.6)	18.6 (15.5-21.7)	12.5 (9.6-15.4)
≥ 27	10.3 (7.0-13.2)	12.9 (10.1-15.7)	7.5 (4.7-10.3)
≥ 30	5.7 (3.4-8.4)	7.3 (4.6-10.0)	4.0 (1.3-5.3)

\*Weighted to the general Pakistani population.

For the primary outcome, we performed logistic regression analysis specific for complex survey designs<sup>21</sup> that accounted for the clusters (primary sampling units), strata (provinces) and data weighted to the general population of Pakistan in 1990, with weights calculated by the Pakistan Federal Bureau of Statistics and confirmed by the US National Center for

Health Statistics for that purpose. The final model included variables that were associated with the outcomes at  $p < 0.05$ . The presence of each of hypertension, diabetes and raised serum cholesterol concentration was then entered into the final model to explore the independent association of BMI with these conditions.

**Table 3:** Association between overweight and obesity (BMI  $\geq 23$  kg/m<sup>2</sup>) and sociodemographic factors in the surveyed Pakistani population aged 15 years or more

Factor	Total no.*	No. (%) overweight or obese*	Unadjusted OR (95% CI)	Adjusted OR (95% CI)†
Age, yr, mean (SD)‡	36.8 (17.3)	39.6 (15.3)	1.08 (1.06-1.10)	1.11 (1.09-1.13)
Ethnicity§				NS
Muhajir	1606	554 (34.5)	1.63 (1.17-1.28)	
Punjabi	3536	859 (24.3)	1.00	
Baluch	282	85 (30.1)	1.05 (0.68-1.64)	
Sindhi	1425	293 (20.6)	0.96 (0.61-1.50)	
Pashtun	1072	292 (27.2)	1.07 (0.69-1.65)	
Other	1051	232 (22.1)	0.90 (0.61-1.34)	
Male	4414	1019 (23.1)	0.73 (0.65-0.81)	0.66 (0.58-0.75)
Female	4558	1296 (28.4)	1.00	1.00
Urban residence	3239	1216 (37.5)	2.36 (1.76-3.16)	2.20 (1.62-2.99)
Rural residence	5733	1099 (19.2)	1.00	1.00
Literate (able to read)	2943	845 (28.7)	1.25 (1.06-1.48)	1.25 (1.09-1.44)
Illiterate (unable to read)	6029	1470 (24.4)	1.00	1.00
Economic status¶				
High	1607	492 (30.6)	1.60 (1.08-2.39)	1.56 (1.06-2.26)
Middle	4396	1206 (27.4)	1.36 (1.06-1.74)	1.14 (0.88-1.46)
Low	2969	617 (20.8)	1.00	1.00
Food intake**				
Meat, high	2719	994 (36.6)	2.13 (1.71-2.65)	1.65 (1.37-1.98)
Meat, low	6253	1321 (21.1)	1.00	1.00
Fruit, high	3224	972 (30.2)	1.34 (1.08-1.65)	NS
Fruit, low	5748	1343 (23.4)	1.00	
Milk, high	4431	1027 (23.2)	0.78 (0.66-0.92)	NS
Milk, low	4541	1288 (28.4)	1.00	
Eggs, high	1434	451 (31.5)	1.44 (1.17-1.77)	NS
Eggs, low	7538	1864 (24.7)	1.00	
Rice, high	2220	620 (27.9)	1.21 (0.95-1.55)	NS
Rice, low	6752	1695 (25.1)	1.00	
Potatoes, high	4672	1252 (26.8)	1.14 (0.90-1.44)	NS
Potatoes, low	4300	1063 (24.7)	1.00	
Use of cigarettes or "beddies"				
Current	1412	328 (23.2)	0.82 (0.69-0.96)	NS
Not current	7560	1987 (26.3)	1.00	
Use of chewable tobacco or snuff				
Current	1003	233 (23.2)	0.83 (0.64-1.07)	NS
Not current	7969	2082 (26.1)	1.00	

Note: OR = odds ratio, CI = confidence interval, SD = standard deviation, NS = not significantly associated with overweight in the multivariable model and therefore not included in the final model.

\*Unless stated otherwise.

†Adjusted for age, sex, urban v. rural dwelling, literacy status, economic status and high v. low intake of meat.

‡Odds ratios are for each 5-year increase.

§Reported as "mother tongue," which is specific for each of the 5 major ethnic subgroups of Pakistan: Muhajir, Punjabi, Baluch, Sindhi and Pashtun.

¶The 3 levels were defined through a simple count of the number of items owned.

\*\*Defined as high if the particular type of food was consumed at least every other day.

The sensitivity and specificity of the BMI for an association with hypertension or diabetes were expressed by receiver operating characteristic (ROC) curves.

## Results

Of the 9442 subjects aged 15 years or more, 470 women reported being pregnant and were excluded from the analysis. Thus, our final sample was 8972 subjects.

The overall prevalence of overweight and obesity, weighted to the general Pakistani population, was 25.0% (95% CI 21.8–28.2%). The prevalence was highest, 42.8%, among women aged 35–54 years but was also high among those aged 15–24 years, at 12.4% for men and 13.8% for women (Table 1). Table 2 shows the weighted prevalence of overweight and obesity according to various BMI cutoff values. The overall weighted prevalence of obesity according to our study definition was 10.3% (95% CI 7.0%–13.2%).

The factors independently and significantly associated with being overweight or obese included greater age, being female, urban residence, being literate, and having a high (v. low) economic status and a high (v. low) intake of meat (Table 3).

Being overweight or obese was independently associated with having hypertension, diabetes and a raised serum cholesterol concentration (Table 4).

The ROC curves (Fig. 1) illustrate the sensitivity and specificity of the BMI for an association with hypertension or diabetes. For hypertension, the optimal cutoff value for the BMI was 21.2 kg/m<sup>2</sup> in both men and women, yielding a sensitivity of 61% and 65% and a specificity of 68% and 63%, respectively. A cutoff value of 23 kg/m<sup>2</sup> had a sensitivity of 43% and 50% and a specificity of 82% and 76% in men and women, respectively. For diabetes, the optimal cutoff value for the BMI was 22.1 kg/m<sup>2</sup> in men and 22.9 kg/m<sup>2</sup> in women, yielding a

sensitivity of 56% and 59%, respectively, and a specificity of 72% in both sexes. A cutoff value of 23 kg/m<sup>2</sup> had a sensitivity of 46% and 59% and a specificity of 78% and 73% in men and women, respectively.

## Interpretation

This nationally representative survey showed 25.0% of the Pakistani population to be overweight or obese according to the Asian-specific BMI cutoff value of 23 kg/m<sup>2</sup> and 10.3% to be obese according to the BMI cutoff value of 27 kg/m<sup>2</sup>. Our data confirm a major public health problem in Pakistan.

Discussions around the global epidemic of obesity have often used the future tense for the developing world. We have shown that current rates of overweight and obesity are already unacceptably high among youths. This is of considerable concern for a number of reasons. Obesity tends to track within individuals and populations: obese children become obese adults. This tendency, combined with the continued trend toward urbanization, will serve to seriously escalate adult levels of obesity: we observed a 2.5 times greater prevalence of obesity among urban residents than among rural residents. In addition, there are indications that obesity in youth coupled with low birth weight is the worst possible combination for adult cardiovascular disease and diabetes, conditions to which Indo-Asian populations are already particularly susceptible.<sup>9</sup>

Critics have challenged the revised BMI thresholds for defining overweight in subpopulations on the grounds that these thresholds may not necessarily be associated with adverse clinical outcomes.<sup>22,23</sup> However, data for Chinese subjects aged 40 years or over revealed a U-shaped association of BMI with 10-year all-cause mortality rates, with the least risk of death at a BMI of less than 21 kg/m<sup>2</sup> among men and less than 22 kg/m<sup>2</sup> among women.<sup>24</sup> We found an inde-

**Table 4:** Association of overweight and obesity (BMI  $\geq$  23 kg/m<sup>2</sup>) with clinical characteristics in the surveyed Pakistani population aged 15 years or more

Clinical characteristic	Total no.*	No. (%) overweight*	Unadjusted OR (95% CI)	Adjusted OR (95% CI)†
Hypertension‡	1757	814 (46.3)	3.20 (2.74-3.74)	2.32 (2.00-2.69)
No hypertension	7215	1501 (20.8)	1.00	1.00
Diabetes mellitus§	482	245 (50.8)	3.05 (2.42-3.86)	2.10 (1.66-2.65)
No diabetes	8490	2070 (24.4)	1.00	1.00
Proteinuria¶	360	111 (30.8)	1.22 (0.88-1.70)	NS
No proteinuria	7388	1946 (26.3)	1.00	
Raised serum cholesterol concentration,** mg/dL, mean (SD)	154.0 (38.1)	168.3 (40.8)	1.06 (1.05-1.08)	1.04 (1.03-1.05)

Note: OR = odds ratio, CI = confidence interval, SD = standard deviation, NS = not significantly associated with overweight in the multivariable model and therefore not included in the final model.

\*Unless stated otherwise.

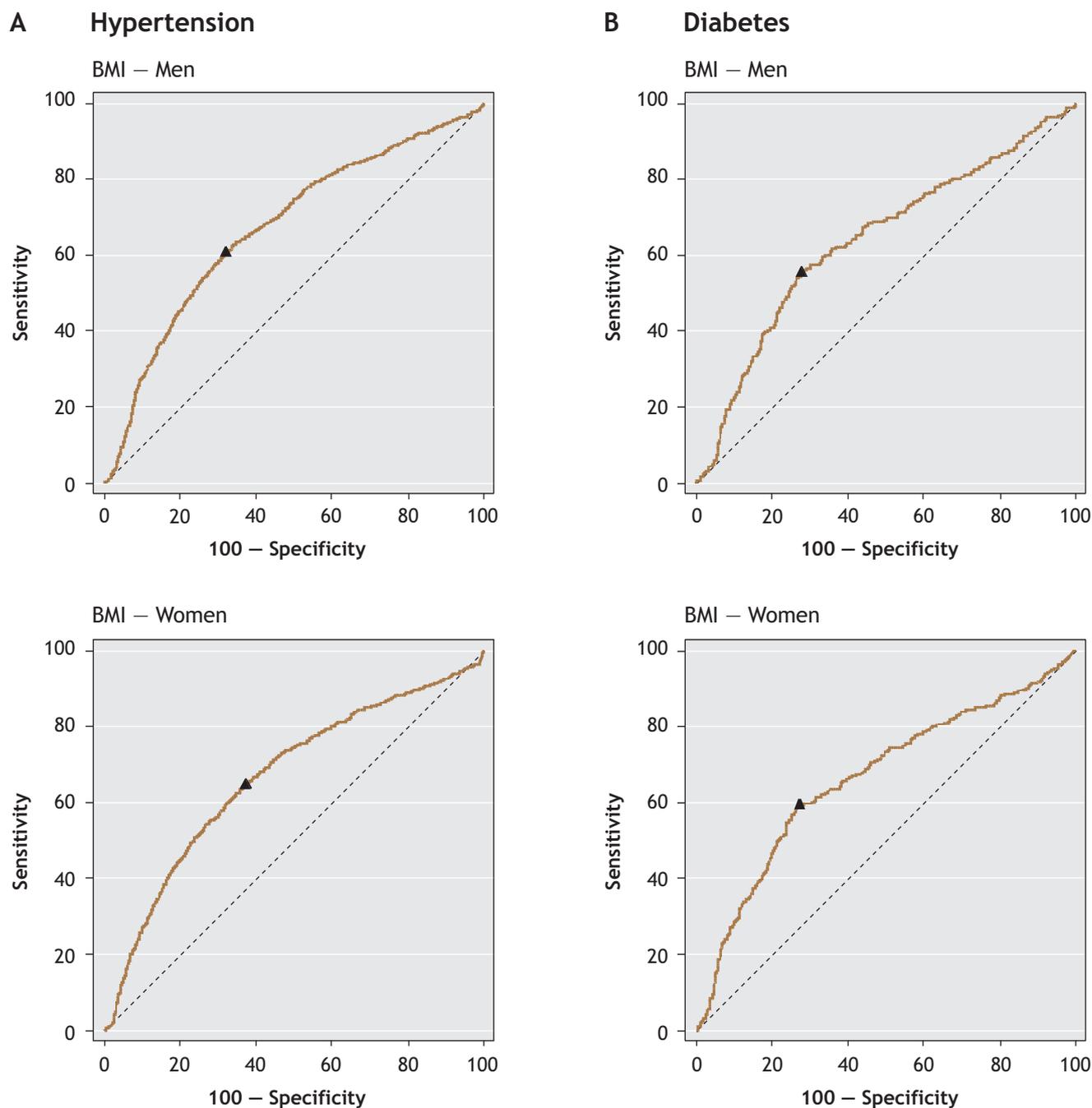
†Based on the multivariable model. Adjusted for age, sex, urban v. rural dwelling, literacy status, economic status and high v. low intake of meat.

‡Defined as having a systolic blood pressure of 140 mm Hg or greater or a diastolic blood pressure of 90 mm Hg or greater (based on the mean of the 2 readings) or currently receiving therapy with antihypertensive medication.

§Defined as having a nonfasting blood glucose concentration of 140 mg/dL (7.8 mmol/L) or greater or a history of diabetes mellitus.

¶Defined as a urine protein concentration of 30 mg/dL or greater as measured by a reagent strip (reading of 1+ or greater). Data on urine protein levels were not available for 1224 people.

\*\*For each increase of 5.0 mg/dL (0.13 mmol/L).



**Fig 1:** Receiver operating characteristic (ROC) curves for the sensitivity and specificity of the association between body mass index (BMI) and hypertension (A) and diabetes mellitus (B). For hypertension in men, the area under the curve (AUC) was 0.68 (95% confidence interval [CI] 0.66–0.69) and the optimal BMI cutoff value 21.2 kg/m<sup>2</sup> (triangle); this BMI value had a sensitivity of 61% and a specificity of 68%. The sensitivity and specificity were 43% and 82%, respectively, for a BMI cutoff value of 23 kg/m<sup>2</sup> and 28% and 90%, respectively, for one of 25 kg/m<sup>2</sup>. For hypertension in women, the AUC was 0.66 (95% CI 0.65–0.68) and the optimal BMI cutoff value 21.2 kg/m<sup>2</sup> (triangle); this value had a sensitivity of 65% and a specificity of 63%. The sensitivity and specificity were 50% and 76%, respectively, for a BMI cutoff value of 23 kg/m<sup>2</sup> and 37% and 85%, respectively, for one of 25 kg/m<sup>2</sup>. For diabetes in men, the AUC was 0.64 (95% CI 0.63–0.66) and the optimal BMI cutoff value 22.1 kg/m<sup>2</sup> (triangle); this value had a sensitivity of 56% and a specificity of 72%. The sensitivity and specificity were 46% and 78%, respectively, for a BMI cutoff value of 23 kg/m<sup>2</sup> and 29% and 88%, respectively, for one of 25 kg/m<sup>2</sup>. For diabetes in women, the AUC was 0.66 (95% CI 0.65–0.68) and the optimal BMI cutoff value 22.9 kg/m<sup>2</sup> (triangle); this value had a sensitivity of 59% and a specificity of 72%. The sensitivity and specificity were 59% and 73%, respectively, for a BMI cutoff value of 23 kg/m<sup>2</sup> and 42% and 82%, respectively, for one of 25 kg/m<sup>2</sup>.

pendent association between a BMI of 23 kg/m<sup>2</sup> or greater and the presence of hypertension, diabetes or a raised serum cholesterol concentration. Further, the ROC curves showed that even lower cutoff values than the recommended 23 kg/m<sup>2</sup> (21.2 and 22.9 kg/m<sup>2</sup> in women and 21.2 and 22.1 kg/m<sup>2</sup> in men), albeit unadjusted for other factors, yielded the optimal areas under the curve for the associations with hypertension and diabetes, respectively. Using a conventional cutoff value of 25 kg/m<sup>2</sup> resulted in poor sensitivity for both associations. Our findings support the use of a lower cutoff value of BMI (23 kg/m<sup>2</sup> or even lower) for identification of subjects with hypertension and diabetes in programs screening for these chronic diseases in Indo-Asian populations.

Our analyses had limitations. Clinical diagnosis of hypertension requires persistent elevation of blood pressure on repeated visits. However, the mean of multiple readings on the same day (2 readings in the National Health Survey of Pakistan) is considered acceptable for epidemiologic studies and has been used to diagnose hypertension in other surveys.<sup>25,26</sup> In the National Health Survey of Pakistan, blood was drawn without a requirement of fasting. Diabetes was defined as a blood glucose concentration of 140 mg/dL (7.8 mmol/L) or greater or a history of diabetes. This definition diverges from the standard criterion of a fasting blood glucose concentration of more than 126 mg/dL (7.0 mmol/L).<sup>19</sup> However, our main findings were unchanged when we performed a sensitivity analysis using the older blood glucose criterion of 200 mg/dL or greater.<sup>28</sup> Thus, we believe that these findings are robust. We acknowledge that some dimensions of socioeconomic status may not have been adequately captured, the food-frequency questionnaire was not validated, and information on physical activity was not collected. In addition, our associations between obesity and health conditions were cross-sectional. However, there have been few high-quality cohort studies in the developing world that have assessed associations between obesity and incident disease, and we believe that reverse causality is not a major problem for conditions that are largely asymptomatic. Moreover, the main objective of our analyses was to determine the nationally representative prevalence of being overweight. Although we also identified some sociodemographic factors associated with being overweight, further, in-depth trials are needed to study the impact of strategies aimed at behaviour change that would target these factors as well as those identified previously in an attempt to reduce the prevalence of being overweight or having central obesity in Pakistan.<sup>27</sup> The sound epidemiologic design, high response rate and use of the modified Asian-specific definition of being overweight or obese are major strengths of our findings, which are generalizable.

In conclusion, our study showed that 1 in 4 people in Pakistan over the age of 15 years is overweight or obese. We have demonstrated alarming rates of obesity among youths and women, indicating where, in particular, interventions should be targeted. Owing to the better association of hypertension and diabetes with an even lower BMI cutoff value (less than 23 kg/m<sup>2</sup>), our findings support the use of Asian-specific thresholds for the definition of being overweight in this pop-

ulation. Immediate efforts are needed at a national level to control this problem in Pakistan and possibly the neighbouring developing countries.

This article has been peer reviewed.

From the Clinical Epidemiology Unit, Department of Community Health Sciences (Jafar, Pappas), and the Section of Nephrology, Department of Medicine (Jafar), Aga Khan University, Karachi, Pakistan; the Division of Nephrology, Department of Medicine, New England Medical Center, Tufts University Medical School, Boston, Mass. (Jafar); and the National Heart and Lung Institute, Imperial College, London, UK (Chaturvedi)

**Competing interests:** None declared.

**Contributors:** Tazeen Jafar was the principal author and contributed to the study concept and design and to the analysis and interpretation of data. Nish Chaturvedi contributed to the study concept and the interpretation of data. Gregory Pappas contributed to the acquisition of data. All of the authors revised the article critically for important intellectual content and gave final approval of the version to be published.

**Acknowledgements:** We thank members of the Pakistan Medical Research Council and the US Department of Health and Human Services for their assistance in the acquisition of data from the National Health Survey of Pakistan.

This study was supported by a grant from the Fogarty International Center, US National Institutes of Health.

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**Correspondence to:** Dr. Tazeen H. Jafar, Director, Clinical Epidemiology Unit, and Head, Section of Nephrology, Medicine and Community Health Sciences, Aga Khan University, PO Box 3500, Stadium Road, Karachi, Pakistan; fax 92-21-4934294; tazeen.jafar@aku.edu

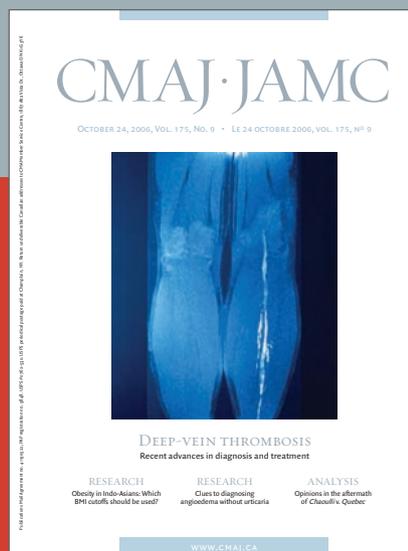
## Editor's take

- The rising prevalence of obesity in industrialized countries is now well documented. It is generally known that people or societies that move from famine to feast go through a time, often a generation, of overeating.
- The authors, in reviewing population survey data, estimate that Pakistan has a high prevalence of overweight and obesity and find that the trend is similar to that already noted in China and other South Asian countries.
- The concern over rates of overweight and obesity in industrialized countries ought to include the entire globe. In Canada, many people are recent immigrants who came from a context of inadequacy to one of plenty. They likely face the same risk of obesity and all its complications.

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