Optimum BMI Cut Points to Screen Asian Americans for Type 2 Diabetes

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EPIDEMIOLOGY/HEALTH SERVICES RESEARCH

OBJECTIVE

Asian Americans manifest type 2 diabetes at low BMI levels but may not undergo diagnostic testing for diabetes if the currently recommended BMI screening cut point of ≥25 kg/m^2 is followed. We aimed to ascertain an appropriate lower BMI cut point among Asian-American adults without a prior diabetes diagnosis.

RESEARCH DESIGN AND METHODS

We consolidated data from 1,663 participants, ages ≥45 years, without a prior diabetes diagnosis, from population- and community-based studies, including the Mediators of Atherosclerosis in South Asians Living in America study, the North Kohala Study, the Seattle Japanese American Community Diabetes Study, and the University of California San Diego Filipino Health Study. Clinical measures included a 2-h 75-g oral glucose tolerance test, BMI, and glycosylated hemoglobin (HbA_{1c}).

RESULTS

Mean age was 59.7 years, mean BMI was 25.4 kg/m^2, 58% were women, and type 2 diabetes prevalence (American Diabetes Association 2010 criteria) was 16.9%. At BMI ≥25 kg/m^2, sensitivity (63.7%), specificity (52.8%), and Youden index (0.16) values were low; limiting screening to BMI ≥25 kg/m^2 would miss 36% of Asian Americans with type 2 diabetes. For screening purposes, higher sensitivity is desirable to minimize missing cases, especially if the diagnostic test is relatively simple and inexpensive. At BMI ≥23 kg/m^2, sensitivity (84.7%) was high in the total sample and by sex and Asian-American subgroup and would miss only ∼15% of Asian Americans with diabetes.

CONCLUSIONS

The BMI cut point for identifying Asian Americans who should be screened for undiagnosed type 2 diabetes should be <25 kg/m^2, and ≥23 kg/m^2 may be the most practical.

The International Diabetes Federation recently reported that Southeast Asia and the Western Pacific region have over half (55%) of the world's 382 million diabetes cases (1). The World Health Organization estimates that by 2030, 7 of the 10 countries with the greatest burden of diabetes cases will be in Asia (2). Similar patterns are recognized in the U.S., where the Diabetes Study of Northern California (DISTANCE) showed that among 2 million members of a large integrated health care system, Pacific Islanders, Filipinos, and South Asians had the highest prevalence and incidence of type 2 diabetes, exceeding those of ethnic groups traditionally known to

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have elevated diabetes risk, including Native Americans, African Americans, and Latinos (3). However, diabetes prevalence and incidence were higher among Southeast Asians, Japanese, Vietnamese, Koreans, and Chinese compared with Caucasians, despite lower BMI (3).

Current American Diabetes Association (ADA) guidelines suggest that diabetes screening should be considered in asymptomatic adults who are overweight (BMI $\geq$25 kg/m^2) and have one or more known risk factors for diabetes, including Asian ethnicity (4). If these risk factors are absent, testing should begin at age 45 years. Lower BMI cut points have been considered to define obesity among Asians (5), but it is not known whether this may also apply to Asian Americans, whose lifestyle behaviors, particularly dietary choices, differ from those of residents of Asia. Previous studies have reported lower BMI among Asian Americans with diabetes; however, they differed in study design, enrollment criteria, and method and time of diabetes ascertainment (6). Recent studies among Asians in Canada and the U.K. have defined BMI cutoff values among Chinese and South Asians that correspond to the equivalent incidence and prevalence of diabetes at a BMI of 30 kg/m^2 in whites (7,8). However, few studies have evaluated BMI cut points for type 2 diabetes screening among Asian Americans using sensitivity, specificity, and receiver operating characteristic (ROC) curve analysis.

The objective of this analysis was to ascertain the BMI cut point that might be most practical for identifying Asian adults ($\geq$45 years) who were found to have previously undiagnosed type 2 diabetes in four clinical cohort studies in the U.S.

RESEARCH DESIGN AND METHODS

We used cross-sectional data from 1,663 Asian Americans enrolled in four different U.S. cohort studies, ages $\geq$45 years, without a prior diabetes diagnosis. Participants were of South Asian, Filipino, Japanese, Chinese, Korean, or mixed Asian ancestry, without non-Asian admixture. The four studies that contributed data included the Mediators of Atherosclerosis in South Asians Living in America (MASALA) study, the North Kohala Study, the Seattle Japanese American Community Diabetes Study (JACDS), and the University of California San Diego (UCSD) Filipino Health Study. These studies were selected because they are clinical studies of multiple health outcomes, thereby reducing self-selection of individuals with diabetes. Further, each of these studies administered a 2-h 75-g oral glucose tolerance test (OGTT), measured weight and height concomitantly, and ascertained whether there was a prior diabetes diagnosis. Glycosylated hemoglobin (HbA$_{1c}$) was measured by high-performance liquid chromatography using an automated analyzer in all cohorts except the Seattle JACDS and Filipino men in San Diego.

UCSD Filipino Health Study

Between 1995 and 1999, 453 Filipino-American women were enrolled as an ethnic comparison group to the Rancho Bernardo Study. Between 2006 and 2007, 109 Filipino-American men were enrolled using the same research protocol and clinic staff. Population-based sampling was not feasible because Filipinos were not disaggregated from other Asian subgroups in the 1990 census, and random digit dialing by last name was impractical because of shared Spanish surnames between Filipinos and San Diego's sizeable Mexican-American population. Community volunteers were recruited at churches, stores, and festivals and through local Filipino media and organizations. Demographic characteristics of participants, particularly with regard to educational attainment, were similar to U.S. census data for Filipina women. Recruitment materials emphasized general health and included tests for osteoporosis and other conditions to reduce self-selection bias for participants with known diabetes (9). Enrollment criteria included age $\geq$40 years, self-reported Filipina, and plans to reside in San Diego for the subsequent 5 years for follow-up.

North Kohala Study

Between 1997 and 2000, a population-based study was conducted among 1,452 nonpregnant residents, ages 18 years and older, in North Kohala, a rural community on the island of Hawaii. Participants were identified by door-to-door census and a cross-reference directory, and community support for the research project was fostered through local public television announcements, flyers posted at community centers and stores, and presentations given to community organizations (10). Participants completed a 4-h clinical examination and interview, including self-reports of ethnic ancestry.

MASALA Study

Between 2010 and 2013, 906 South Asian men and women were enrolled at two clinical centers (the University of California, San Francisco, San Francisco, CA, and Northwestern University, Chicago, IL). Eligibility criteria, recruitment, and study methods have been described previously (11). Sampling was performed using South Asian last name samples from commercial mailing list companies at each site. To be eligible, participants had to self-report South Asian ethnicity, be between 40 and 84 years of age, and be able to speak and/or read English, Hindi, or Urdu. Individuals with any known cardiovascular disease (CVD) or history of cardiovascular procedures were excluded from this study (11).

Seattle JACDS

This study included only individuals of pure Japanese ancestry residing in King County, WA, who were Nisei (second-generation children of immigrants from Japan) or Sansei (third-generation children of the Nisei). Recruitment began in 1983 with a volunteer sample of Nisei men (*n* = 229). The study sample was expanded in 1986 to include Nisei women (*n* = 191) and Sansei men (*n* = 120) and women (*n* = 118) (12–14). Nisei participants were selected to oversample self-reported diabetic individuals in order to compare diabetic with nondiabetic individuals. Although the study participants were volunteers, they were shown to be very similar in terms of several demographic characteristics to the overall Japanese-American population of King County (12,13). Baseline examinations were carried out from 1983 to 1986 for Nisei men, from 1986 to 1988 for Nisei women, and from 1988 to 1991 for all Sansei.

Demographic characteristics obtained from all studies included age, sex, self-reported ethnicity and admixture, and medical history, including prior diagnosis of type 2 diabetes by a physician. Self-reported ethnicity was ascertained through multiple questions including the following: participant's province and country of birth, parents' birthplace, and participant's description of their race/ethnicity (UCSD Filipino Health Study); an estimate of the participant's percentage ancestry for each of eight of the most common ethnic groups in Hawaii and which ethnic group they strongly identify with (North Kohala Study); if at least three grandparents were born in a South Asian country and the participant's province/state and country of birth (MASALA); and if both parents and all four grandparents were Japanese (Seattle JACDS).

Clinical measures included height using a standardized stadiometer and weight by standard balance beam or digital scale, with participants wearing lightweight clothing and no shoes. BMI was computed as weight divided by height squared in metric units. A 2-h 75-g OGTT was administered after a minimum 8-h fast. HbA_{1c} was measured except among Filipino men in San Diego and Japanese men and women in Seattle. Plasma glucose was measured by the glucose oxidase method and HbA_{1c} by high-performance liquid chromatography.

Type 2 diabetes was defined by ADA criteria (2010) as HbA_{1c} ≥6.5% (48 mmol/mol), fasting plasma glucose (FPG) ≥126 mg/dL (6.99 mmol/L), or 2-h post–75-g glucose challenge glucose (PPG) ≥200 mg/dL (11.1 mmol/L) (4).

Statistical Analysis

Descriptive analyses were performed and presented as percentages or means (and SD values) for categorical and continuous covariates, respectively. Mean values of continuous covariates were compared using independent Student *t* tests or ANOVA in unadjusted comparisons and general linear models in age-adjusted comparisons. Pearson χ^2 test was used for categorical variables. All *P* values were two sided, with $P < 0.05$ considered statistically significant. Age-adjusted prevalence was computed by the direct method.

Sensitivity, specificity, and positive predictive values were computed at 1-unit increments of BMI, ranging from 22 to 27.5 kg/m^2. This BMI range was selected to include BMI values recommended by the World Health Organization to define overweight (23 kg/m^2) and obesity (27.5 kg/m^2) among Asians (5). At each BMI cut point, sensitivity was calculated as the proportion with type 2 diabetes and a BMI value equal to or greater than the BMI cut point among all individuals with type 2 diabetes; specificity was the proportion without type 2 diabetes and a BMI lower than the specific BMI cut point among all individuals without type 2 diabetes; and positive predictive value was computed as the proportion with type 2 diabetes and a BMI equal to or greater than the BMI cut point. Area under the receiver operating characteristic curve (AUROC) for logistic regression models was computed using the c statistic. Statistical analyses were performed using SAS version 9.2 (SAS Institute, Cary, NC).

Optimal BMI cut points were evaluated using several criteria, including *1*) Youden index (sensitivity + specificity − 1); *2*) misclassification rate (false-negative + false-positive rate); *3*) the BMI cut point where sensitivity approximated specificity; and *4*) where sensitivity approximated 80%. BMI cut points were evaluated for the total sample, by sex, and by Asian-American subgroup.

RESULTS

Participants included 536 Filipinos (421 from the UCSD Filipino Health Study and 115 from the North Kohala Study), 500 Japanese (371 from Seattle JACDS and 129 from North Kohala), 609 South Asians from the MASALA study, and 18 of Chinese, Korean, or mixed East Asian ancestry (from the North Kohala Study). Collectively, 58% were women, and whereas sex was evenly divided among Japanese and South Asians, three-fourths of Filipinos were women (Table 1). Mean age was 59.7 years (SD 9.2), ranging from 45 to 95 years, with South Asians being

Table 1—Age-adjusted demographic and clinical characteristics: Filipinos, Japanese, and South Asians in the U.S., aged ≥45 years

	Filipino, San Diego and Hawaii, *n* = 536	Japanese, Hawaii and Seattle, *n* = 500	South Asian, San Francisco and Chicago, *n* = 609
Men (*n*)	121	254	311
Women (*n*)	415	246	298
Mean age (years)	61.3‡ (9.5)	61.3† (9.1)	56.9 (8.3)
Men	68.1*,‡ (8.4)	61.0† (9.0)	58.0 (9.0)
Women	59.3‡ (8.9)	61.6*,† (9.1)	55.7 (7.4)
Mean BMI (kg/m^2)	25.5* (3.8)	24.9 (3.6)	25.8† (4.5)
Men	26.6 (3.8)	25.7 (3.2)	25.7 (4.6)
Women	25.3* (3.8)	23.8 (3.6)	26.0†,‡ (4.4)
Mean waist (cm)	84.1*,‡ (11.3)	88.2† (9.9)	92.5 (10.0)
Men	93.3* (10.3)	90.1 (9.2)	95.4† (9.0)
Women	81.7 (10.2)	86.4* (10.2)	89.0†,‡ (9.9)
Fasting glucose (mg/dL) (mmol/L)	101.6‡ (20.2) 5.65 (1.12)	101.0† (19.5) 5.62 (1.08)	98.8 (19.0) 5.46 (1.00)
2-h glucose (mg/dL) (mmol/L)	157.6*,‡ (65.7) 8.79 (3.64)	148.7† (53.5) 8.31 (2.97)	139.3 (53.2) 7.64 (2.95)
HbA_{1c} (%)	5.68* (0.99)	4.85 (0.82)	5.88† (0.55)
HbA_{1c} (mmol/mol)	39 (10.8)	29 (9.0)	41 (6.0)
Age-adjusted diabetes prevalence (%)			
Diabetes, ADA 2010	22.8*,‡	12.9	13.0
By HbA_{1c} ≥6.5% (≥48 mmol/mol)	12.2*,‡	4.2	6.8
By FPG ≥126 mg/dL (≥6.99 mmol/L)	5.4	4.8	3.9
By 2-h PPG ≥200 mg/dL (≥11.1 mmol/L)	19.4*,‡	11.9	11.0

Data are mean (SD) unless otherwise indicated. Eighteen participants of Chinese, Korean, or mixed East Asian ancestry are not represented. There were no HbA_{1c} data for San Diego Filipino men and Seattle Japanese. *$P < 0.05$, Filipino vs. Japanese. †$P < 0.05$, Japanese vs. South Asian. ‡$P < 0.05$, Filipino vs. South Asian.

slightly younger compared with either Filipinos or Japanese ($P < 0.05$). Mean BMI was 25.4 kg/m^2 (SD 4.0, range 14.6–67.1 kg/m^2). Average BMI was similar by ethnicity among men but was significantly lower among Japanese women compared with either Filipinos or South Asian women and was significantly lower among Filipino women compared with South Asian women.

Collectively, mean FPG was 5.58 mmol/L (100.5 mg/dL, SD 19.3) and was significantly lower among South Asians compared with Filipinos or Japanese. Mean PPG was 8.22 mmol/L (148.1 mg/dL, SD 58.3) and was significantly higher among Filipinos compared with the other two groups and significantly higher among Japanese compared with South Asians. HbA_{1c} was not measured among Japanese in Seattle or Filipino men in San Diego. Mean HbA_{1c} was 5.69% (SD 0.84) (39 mmol/mol, SD 9.2) and was significantly higher among South Asians compared with either group and significantly higher among Filipinos compared with Japanese.

A total of 1,663 participants had FPG and PPG measures; of these, only 1,214 (73%) had HbA_{1c} measures. Using any of these criteria, cumulative diabetes prevalence was 16.9% in the sample of 1,663 adults. When stratified by Asian-American subgroup, age-adjusted newly diagnosed type 2 diabetes prevalence was significantly higher among Filipinos (22.8%) compared with either Japanese (12.9%) or South Asians (13.0%) ($P < 0.001$) and did not differ between Japanese and South Asians ($P = 0.78$). These observations persisted when diabetes was diagnosed by either HbA_{1c} or PPG but did not differ by Asian-American subgroup when diabetes was defined by FPG only. When stratified by diagnosis method, 112 (9.2%) had HbA_{1c} $\geq$6.5% (48 mmol/mol), 83 (5.0%) had FPG $\geq$126 mg/dL (6.99 mmol/L), and 244 (14.7%) had PPG $\geq$200 mg/dL (11.1 mmol/L).

Among the 1,214 participants with all three diagnostic measures, type 2 diabetes prevalence was 18.4% (n = 223). Of these, 9.2% (n = 112) fulfilled the HbA_{1c} criterion, 5.5% (n = 67) met the FPG criterion, and 15.5% (n = 188) met the PPG criterion. If screening was limited to HbA_{1c}, half (50%) of Asian Americans with diabetes would remain undiagnosed. If FPG was added, an additional, albeit minimal (n = 14), 1.2% would be diagnosed. The remaining 44% (n = 97) of Asian Americans with type 2 diabetes would remain undiagnosed without the PPG since they had isolated postchallenge hyperglycemia (with both HbA_{1c} and FPG not diagnostic of diabetes).

The area under the BMI-diabetes ROC curve was 0.617. This low AUROC value reflects the poor sensitivity of BMI in predicting type 2 diabetes in an Asian-American population. Among the 281 participants without a prior diagnosis of type 2 diabetes, BMI at the time of diagnosis is shown in Fig. 1. Although the mean BMI at the time of diabetes diagnosis was 26.7 kg/m^2, 37% of women and 21% of men with diabetes had a BMI $\leq$24.9 kg/m^2 and may otherwise not be screened if the recommended threshold criterion for screening of BMI $\geq$25 kg/m^2 is used.

Table 2 shows the sensitivity, specificity, positive predictive value, and misclassification rate in the total sample and by sex. Sensitivity varied widely, ranging from 90.8 to 36%; however, the misclassification rate was similar across BMI cut points, ranging from 0.87 at BMI $\geq$23 kg/m^2 to 0.83 at BMI $\geq$27 kg/m^2. The positive predictive value was low across all BMI cut points, ranging from 19.5% at BMI $\geq$23 kg/m^2 to 25% at BMI $\geq$27 kg/m^2. The BMI cut point with the highest Youden index and the lowest misclassification rate was 26 kg/m^2; however, limiting screening at this cut point would miss almost half (48.4%) of Asian Americans with previously undiagnosed diabetes. The BMI cut point where sensitivity approximated specificity was 25.2 kg/m^2, but limiting screening to this cut point would miss 39.5% of Asian Americans with previously undiagnosed type 2 diabetes.

Figure 2 shows sensitivity values by Asian-American subgroup at each BMI cut point. Sensitivity declined with increasing BMI and varied widely, although Youden index values varied minimally across BMI cut points. At a BMI $\geq$23 kg/m^2, sensitivity was 89.8% for Filipinos, 84.2% among South Asians, and 79.1% for Japanese. Sensitivity declined with a higher cut point at BMI $\geq$25 kg/m^2, ranging from 62.7% among Filipinos, to 65.7% in Japanese, to 67.1% among South Asians. Limiting screening to this BMI cut point would miss diabetes diagnosis in 37% of Filipinos, 34% of Japanese, and 33% of South Asians.

Youden index values were low, and misclassification rates were high, and values were relatively similar across BMI cut points, thereby limiting their usefulness in identification of optimal BMI cut points. Therefore, to reduce missing potential cases of type 2 diabetes, a targeted sensitivity of 80% was used as a final criterion to assess optimal BMI cut points for identifying Asian Americans who should undergo diabetes screening. In the total sample, as well as for men and women, a BMI cut point of $\geq$23.5 kg/m^2 produced sensitivity approximating 80% (Fig. 2).

When stratified by subgroup, BMI cut points of 23.6 kg/m^2 among Filipinos, 23.4 kg/m^2 among South Asians, and 22.8 kg/m^2 among Japanese Americans

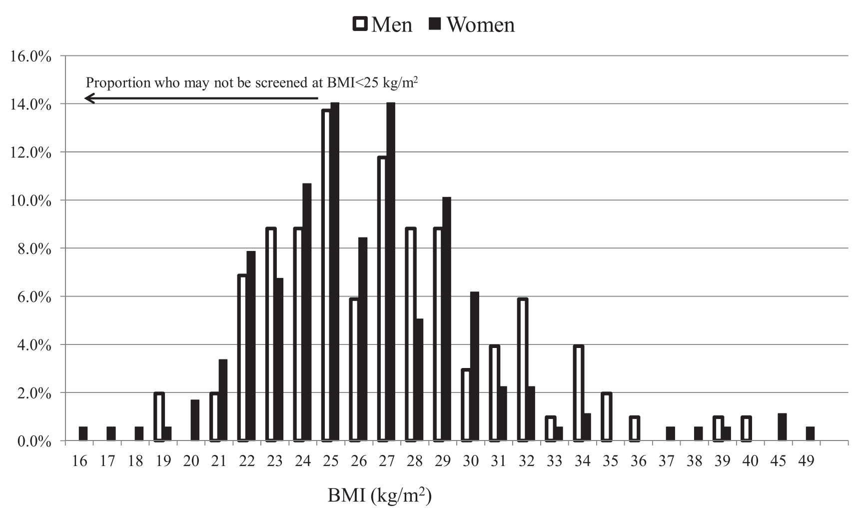

Figure 1—Percent distribution of Asian Americans with newly diagnosed type 2 diabetes by BMI.

Table 2—Sensitivity, specificity, positive predictive value, and AUROC among Asian-American adults, aged ≥45 years, without known type 2 diabetes

BMI (kg/m^2)	Diabetes (*n* [%])	Sensitivity (%)	Specificity (%)	PPV (%)	Misclassification rate
Total	*N* = 1,663				
≥22	255 (15.3)	90.8	18.4	15.3	0.91
≥23	238 (14.3)	84.7	28.8	19.5	0.87
≥24	208 (12.5)	74.0	40.7	20.3	0.85
≥25	179 (10.8)	63.7	52.8	21.5	0.84
≥26	145 (8.7)	51.6	65.3	23.2	0.83
≥27	122 (7.3)	43.4	73.6	25.1	0.83
≥27.5	102 (6.1)	36.3	77.8	24.9	0.86
Women	*n* = 970				
≥22	159 (16.4)	89.3	22.4	20.5	0.88
≥23	150 (15.5)	84.3	33.2	22.1	0.83
≥24	131 (13.5)	73.6	45.8	23.4	0.81
≥25	112 (11.6)	62.9	57.1	24.8	0.80
≥26	90 (9.3)	50.6	68.4	26.5	0.81
≥27	74 (7.6)	41.6	76.1	28.1	0.82
≥27.5	60 (6.2)	33.7	79.4	26.9	0.87
Men	*n* = 693				
≥22	96 (13.9)	93.2	13.1	15.8	0.94
≥23	88 (12.7)	85.4	22.9	16.2	0.92
≥24	77 (11.1)	74.8	33.9	16.5	0.91
≥25	67 (9.7)	65.1	47.1	17.7	0.88
≥26	55 (7.9)	53.4	61.0	19.3	0.86
≥27	48 (6.9)	46.6	70.2	21.4	0.83
≥27.5	42 (6.1)	40.8	75.6	22.6	0.84

PPV, positive predictive value.

yielded sensitivity values approximating 80%. When stratified by diabetes diagnostic criteria, sensitivity approached 80% at BMI ≥24.0 kg/m^2 among participants diagnosed by HbA_{1c} ≥6.5% (48 mmol/mol), at BMI ≥23.4 kg/m^2 among those diagnosed by FPG ≥126 mg/dL (6.99 mmol/L), and at BMI ≥23.2 kg/m^2 among Asian Americans with isolated postchallenge hyperglycemia.

The identification of a BMI cut point that has higher sensitivity would be economically and clinically practical to identify Asian Americans who should undergo diabetes screening.

Screening Asian Americans at BMI ≥23 kg/m^2 had a sensitivity of 84.7% and would miss identification of ~15.3% of Asian Americans with type 2 diabetes. Further, screening Asian Americans at BMI ≥23 kg/m^2 might facilitate identification of Asian Americans with isolated postchallenge hyperglycemia. When analyses included younger participants, BMI ≥23 kg/m^2 persisted as the optimal cut point for those aged ≥35 years (*n* = 2,042) or ≥40 years (data not shown).

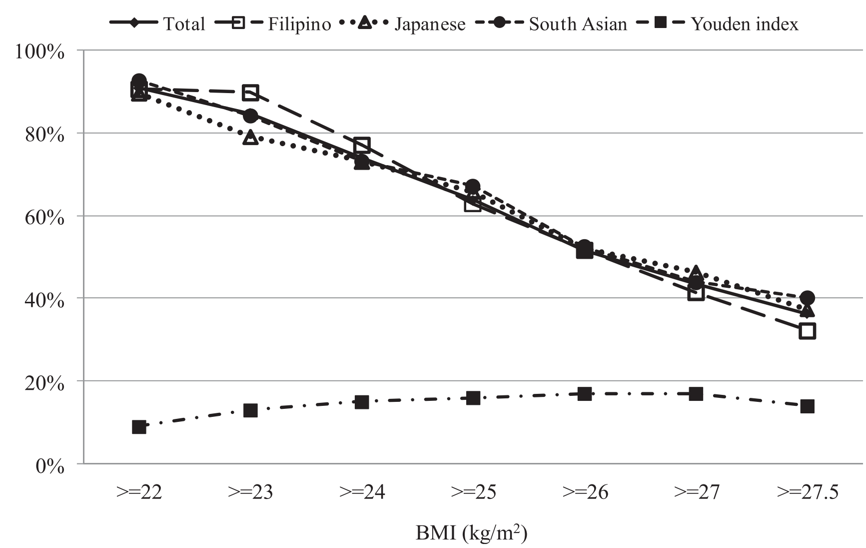

Figure 2—Sensitivity and Youden index at selected BMI cut points.

CONCLUSIONS

In the absence of a national, multicenter, prospective cohort study of Asian Americans, our combined data from our four community-based studies showed that age-adjusted diabetes prevalence (16.9%) by OGTT was high among Asian-American adults without a prior diabetes diagnosis. However, limiting screening to HbA_{1c} and fasting glucose measures fails to identify almost half of Asian Americans with type 2 diabetes. Current recommendations to screen asymptomatic Americans with BMI ≥25 kg/m^2 produced low sensitivity and specificity and would fail to identify over one-third of Asian Americans with type 2 diabetes. Diabetes screening at a lower BMI cut point of ≥23 kg/m^2 should be considered since it improves sensitivity and would enable early diagnosis and management of Asian Americans with type 2 diabetes. BMI alone cannot predict incident diabetes, but our data suggest that a BMI cut point of ≥23 kg/m^2 can be a practical initial screening tool to identify Asian Americans who may have or be at risk for diabetes. The U.S. Preventive Services Task Force recently changed its position to broaden screening for diabetes and prediabetes, supporting a wider BMI approach to screening. BMI serves as a trigger point for action (15).

There is now ample evidence that diabetes is present among Asian Americans at a higher frequency than in the non-Hispanic white population. Since the costs associated with type 2 diabetes are mainly attributable to the management and consequences of complications associated with this disease and since these complications are related to both duration and severity of hyperglycemia, it is important to identify individuals who may be at increased risk for diabetes to institute therapy in a timely manner. Rates of diabetes-related complications have reduced significantly in the past two decades (16), and this may be due to improved glucose control.

Increased body size as manifested by greater body weight and BMI has been recognized to identify people who are at risk for diabetes. However, many Asian Americans who have documented type 2 diabetes do not appear to be very heavy (6). Excess visceral fat accumulation, assessed by computed tomography, was observed among Filipino Americans (even with BMI $<$23 kg/m^2) compared with normal-weight Caucasians and African Americans (17). Temporal change in intra-abdominal fat area, independent of BMI, was predictive of incident diabetes among Japanese Americans with normal BMI (24.2 kg/m^2) (18). Thus in clinical practice, Asian Americans are likely to be overlooked as being at risk for type 2 diabetes by BMI cutoff criteria for overweight and obesity that are more useful for non-Asian populations. Our findings support the view that a lower BMI cut point is appropriate for identifying Asian Americans who should be screened for undiagnosed type 2 diabetes, and our proposed BMI cut point of 23 kg/m^2 is within the range of other observations among Asian British and Asian Canadians. For the equivalent prevalence of diabetes at 30 kg/m^2 in white participants, BMI equated to 22 kg/m^2 among South Asians in the UK Biobank study (7) and to 24 kg/m^2 among South Asians in Canada (8). Both studies had a sizeable number of Chinese participants but no Japanese or Filipino participants, so comparisons to our findings were not feasible for these Asian subgroups.

Both studies identified different BMI cut points for Chinese and South Asians, ranging from 25 to 26 kg/m^2 and 22 to 24 kg/m^2, respectively. Asian Americans are heterogeneous with regard to diabetes prevalence and risk, but identifying and implementing BMI cut points for each Asian subgroup is impractical. A single BMI cut point from a public health standpoint that is simple to use is critical as we continue to face a high rate of undiagnosed diabetes in the U.S., while appreciating the need for an individualized approach on the patient level according to other risk factors, including ethnicity.

Clinical and diagnostic tests are characterized by both sensitivity and specificity. There are multiple criteria for defining optimum cut points for such testing, and these vary by disease as well as the cost and convenience of the test. Generally speaking, for diagnosis of a disease, specificity is highly desirable. For screening, however, it is preferable to be more inclusive rather than exclusive to minimize overlooking at-risk cases. This is particularly the case if the screening test is not costly and definitive diagnosis of the disease for which screening is being conducted is also economical. The costs associated with determining BMI are negligible, and the costs of the diagnostic test for type 2 diabetes are reasonable. The cost of performing an OGTT involves a glucose solution and test administration after 2 h and is suitably higher than that of an FPG test.

BMI is a useful first-step screening test for the identification of patients at risk for diabetes. A BMI cut point that has higher sensitivity despite lower specificity would be economically and clinically practical to identify Asian Americans who should undergo further glucose testing for type 2 diabetes. Based upon our examination of the extant literature and the data from the current analysis, we have examined the criteria for defining the BMI cutoff value based upon sensitivity and suggest that BMI $\geq$23 kg/m^2 may be appropriate. Although reduction in this cutoff will lead to more people being tested and found to be without diabetes, there may be value in this determination to those tested in reassuring them of the absence of this common metabolic disease.

Screening guidelines should also consider the value of the OGTT, particularly among Asian Americans. Limiting screening to just HbA_{1c} and FPG failed to identify 44% of Asian Americans with type 2 diabetes, specifically those with isolated postchallenge hyperglycemia. Isolated impaired glucose tolerance and postchallenge hyperglycemia are common features among South Asians, Japanese, and Filipinos (19–21), reflecting normal to slightly reduced hepatic insulin sensitivity, moderate to severe muscle insulin resistance, and a severe deficit in late-phase insulin secretion (22). Such differences in the pathophysiology of type 2 diabetes among Asians compared with other ethnic groups reinforce the importance of the 2-h OGTT for early diagnosis of type 2 diabetes among Asian Americans.

The strengths of the current analysis include data obtained from population-based or community health studies where participants were recruited for general health outcomes. The North Kohala Study was population based and included young residents, ages 20 years and older. The MASALA study was population based and used telephone recruitment based on last name lists and excluded participants with CVD, thereby possibly reducing self-selection of participants with CVD comorbidities, including type 2 diabetes. In San Diego, recruitment materials emphasized multiple health outcomes, including osteoporosis, to reduce self-selection of participants with CVD or type 2 diabetes. The Japanese cohort in Seattle was based on a volunteer sample that was representative of Japanese Americans in Seattle (23). All four studies queried participants about their medical history and current medication, and the current analysis excluded those with a physician diagnosis of type 2 diabetes, as well as those taking insulin or oral hypoglycemic agents. The few existing studies on diabetes prevalence among Asian Americans have been based on self-report, medical records, HbA_{1c}, or FPG, such that individuals with isolated postchallenge hyperglycemia are missed (20). In our analysis, diabetes ascertainment was complete since it was based on OGTT in all 1,663 participants. Further, diabetes was ascertained by all three methods, including HbA_{1c} and fasting and postchallenge glucose, in 1,214 participants. Finally, to our knowledge, this is the first analysis to assess sensitivity, specificity, positive predictive value, and misclassification rates at every BMI cut point in pooled samples of Asian-American study populations.

Several study limitations require acknowledgment, particularly the absence of available data from Chinese, Vietnamese, and Korean cohorts in the U.S. Our sample was limited to just 18 Chinese, Korean, and mixed-Asian participants in the North Kohala Study, which was population based. Chinese migration to the U.S. began over a century ago, and Chinese Americans comprise the largest Asian-American subgroup. Vietnamese and Koreans comprise the fourth and fifth largest Asian-American subgroups, respectively, exceeding the Japanese-American population. However, there are no clinical cohorts of these Asian-American subgroups that include OGTT measures. Data from the DISTANCE study showed that Chinese Americans with either incident or prevalent diabetes had lower BMI compared with Filipinos and South Asians (3); therefore, our observation of an optimal BMI screening cut point of $\geq$23 kg/m^2 might also be appropriate for Americans of Chinese descent. Our collective sample size was small compared with the DISTANCE and UK Biobank studies; however, to our knowledge, our data represent all population- and community-based clinical cohorts of Asian Americans where diabetes was ascertained by OGTT. Prospective studies among aggregate Asian-American subgroups must be established to better understand the unique pathophysiology of diabetes among Asian Americans and establish appropriate screening, prevention, and treatment interventions.

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