Annals of Internal Medicine

ORIGINAL RESEARCH

Diabetes Screening by Race and Ethnicity in the United States: Equivalent Body Mass Index and Age Thresholds

Rahul Aggarwal, MD; Kirsten Bibbins-Domingo, MD, PhD; Robert W. Yeh, MD, MSc; Yang Song, MS; Nicholas Chiu, MD, MPH; Rishi K. Wadhera, MD, MPP, MPhil; Changyu Shen, PhD; and Dhruv S. Kazi, MD, MSc, MS

Background: Racial/ethnic minority populations in the United States have increased rates of diabetes compared with White populations. The 2021 guidelines from the U.S. Preventive Services Task Force recommend diabetes screening for adults aged 35 to 70 years with a body mass index (BMI) of 25 kg/m^2 or greater.

Objective: To determine the BMI threshold for diabetes screening in major racial/ethnic minority populations with benefits and harms equivalent to those of the current diabetes screening threshold in White adults.

Design: Cross-sectional study.

Setting: NHANES (National Health and Nutrition Examination Survey), 2011 to 2018.

Participants: Nonpregnant U.S. adults aged 18 to 70 years (n = 19 335).

Measurements: A logistic regression model was used to estimate diabetes prevalence at various BMIs for White, Asian, Black, and Hispanic Americans. For each racial/ethnic minority group, the equivalent BMI threshold was defined as the BMI at which the prevalence of diabetes in 35-year-old persons in that group is equal to that in 35-year-old White adults at a BMI of 25 kg/m^2. Ranges were estimated to account for the uncertainty in prevalence estimates for White and racial/ethnic minority populations.

Results: Among adults aged 35 years with a BMI of 25 kg/m^2, the prevalence of diabetes in Asian Americans (3.8% [95% CI, 2.8% to 5.1%]), Black Americans (3.5% [CI, 2.7% to 4.7%]), and Hispanic Americans (3.0% [CI, 2.1% to 4.2%]) was significantly higher than that in White Americans (1.4% [CI, 1.0% to 2.0%]). Compared with a BMI threshold of 25 kg/m^2 in White Americans, the equivalent BMI thresholds for diabetes prevalence were 20 kg/m^2 (range, <18.5 to 23 kg/m^2) for Asian Americans, less than 18.5 kg/m^2 (range, <18.5 to 23 kg/m^2) for Black Americans, and 18.5 kg/m^2 (range, <18.5 to 24 kg/m^2) for Hispanic Americans.

Limitation: Sample size limitations precluded assessment of heterogeneity within racial/ethnic groups.

Conclusion: Among U.S. adults aged 35 years or older, offering diabetes screening to Black Americans and Hispanic Americans with a BMI of 18.5 kg/m^2 or greater and Asian Americans with a BMI of 20 kg/m^2 or greater would be equivalent to screening White adults with a BMI of 25 kg/m^2 or greater. Using screening thresholds specific to race/ethnicity has the potential to reduce disparities in diabetes diagnosis.

Primary Funding Source: Richard A. and Susan F. Smith Center for Outcomes Research in Cardiology.

Ann Intern Med. 2022;175:765-773. doi:10.7326/M20-8079 **Annals.org**
For author, article, and disclosure information, see end of text.
This article was published at Annals.org on 10 May 2022.

Diabetes mellitus is a leading cause of morbidity and mortality in the United States, affecting more than 34 million adults and generating $330 billion in annual health care expenditures (1, 2). Persons with overweight or obesity are at increased risk for diabetes compared with those with normal weight (3). The U.S. Preventive Services Task Force (USPSTF) previously recommended screening for diabetes among adults aged 40 to 70 years who have a body mass index (BMI) of 25 kg/m^2 or greater; in August 2021, the USPSTF changed the starting age for this recommendation to 35 years. The goal of screening would be to identify individuals who may benefit from intensive behavioral counseling, interventions to improve diet and physical activity, or pharmacologic therapy (4, 5).

Compared with White populations, persons in racial/ethnic minority populations in the United States have a higher prevalence of diabetes, are less likely to be aware of their diagnosis, and are more likely to die of diabetes (3, 4, 6). A risk-based screening approach may suggest that diabetes screening should be offered starting at lower BMIs and younger ages in racial/ethnic minority populations. The American Diabetes Association recommends that Asian Americans be considered for screening starting at lower BMIs, and the 2021 recommendations that the USPSTF released recently acknowledge that some racial/ethnic groups are at higher risk and may warrant screening at lower ages or BMIs (3–5, 7). Personalizing screening recommendations by race/ethnicity could increase diagnosis rates and improve health equity (8).

In this study, we determined the equivalent BMI thresholds for diabetes screening among racial/ethnic minority Americans that would be expected to produce similar tradeoffs of screening-related benefits and harms to the implementation of the 2021 USPSTF recommendations in White Americans. In secondary analyses, we identified whether initiating screening at younger ages in persons from racial/ethnic minority groups would be equivalent to the current practice of screening White persons starting at age 35 years.

See also:

Editorial comment. 895
Summary for Patients I-22

Web-Only
Supplement

METHODS

Data Source

NHANES (National Health and Nutrition Examination Survey) is a cross-sectional survey designed to produce nationally representative estimates of risk factors and disease prevalence in major racial/ethnic groups. It is conducted every 2 years by the National Center for Health Statistics (9). NHANES was approved by the National Center for Health Statistics Research Ethics Review Board. We included in our analyses the 4 NHANES cycles from 2011 to 2018—all cycles that oversample Asian Americans and Hispanic Americans (in addition to the more long-standing practice of oversampling Black Americans).

Study Participants and Definitions

Age and race/ethnicity in NHANES were determined by self-report. Our study included 19 335 nonpregnant adults aged 18 to 70 years (the age group eligible for screening in the 2021 USPSTF recommendations [4]), including 6319 White Americans, 2658 Asian Americans, 4597 Black Americans, 4998 Hispanic Americans, and 763 Americans from other racial/ethnic populations. Although NHANES further categorizes Hispanic Americans as either Mexican American or other Hispanic American, we grouped the 2 categories when evaluating screening thresholds because of limited sample size (particularly among adults with normal weight). The White, Asian, and Black American categories included only persons identifying as non-Hispanic. Those who self-identified as belonging to other races/ethnicities were included in the analyses to appropriately account for the NHANES survey design, but we do not present results for these persons because of a lack of more granular information on race/ethnicity.

Survey participants were determined to have diabetes if they had a hemoglobin A_{1c} level of at least 6.5% or responded "yes" to the survey question asking whether a health care professional had diagnosed them with diabetes (a sensitivity analysis also included persons with a fasting blood glucose level ≥7.0 mmol/L [≥126 mg/dL], as described in the following section). Diabetes was determined to be undiagnosed if participants met criteria for the condition but responded "no" or "don't know" to the question about professional diagnosis. These outcomes were similarly defined in prior surveillance reports, including those from the Centers for Disease Control and Prevention (CDC) (1, 10).

Persons participating in NHANES had in-person examinations of height and weight, and BMI was computed by dividing a person's weight in kilograms by the square of their height in meters. The following 4 BMI categories were defined per CDC recommendations: underweight (BMI <18.5 kg/m^2), normal weight (BMI, 18.5 to 24.9 kg/m^2), overweight (BMI, 25.0 to 29.9 kg/m^2), and obese weight (BMI ≥30.0 kg/m^2) (11).

Outcomes and Measures

We estimated the prevalence of diabetes and undiagnosed diabetes by racial/ethnic group among adults aged 35 to 70 years (the population in which diabetes screening is recommended per the USPSTF guidelines; *n* = 12 921 in our study cohort). We then examined the prevalence of diabetes and undiagnosed diabetes by race/ethnicity and BMI category. We used logistic regression models to estimate the odds of prevalent diabetes (or undiagnosed diabetes) in each racial/ethnic minority population compared with White populations (additional details are in the Statistical Analysis section). In sensitivity analyses, we used the following alternative end points: a composite outcome of prediabetes or diabetes (prediabetes defined as a hemoglobin A_{1c} level from 5.7% to <6.5% in persons without diabetes), an expanded definition of diabetes that included an abnormal fasting blood glucose level suggestive of diabetes (≥7 mmol/L [≥126 mg/dL]), and an alternative definition of diabetes requiring abnormalities in both hemoglobin A_{1c} level (≥6.5%) and fasting glucose level (≥7 mmol/L [≥126 mg/dL]) for diagnosis of diabetes by laboratory measurements. Of note, because fasting blood glucose results were available for only a subset of NHANES participants, the sample size for analyses using fasting glucose levels was reduced to 4923 persons.

Among U.S. adults aged 18 to 70 years with a BMI of 15 to 50 kg/m^2, we used a logistic regression model to estimate the prevalence of diabetes by race/ethnicity, age, and BMI. We used this model to estimate the prevalence of diabetes at each BMI level from 18.5 to 25 kg/m^2 among U.S. adults aged 35 years in each major racial/ethnic group (additional modeling details are in the Statistical Analysis section and in the Supplement, available at Annals.org).

We used the following approach to determine an equivalent screening threshold by race/ethnicity. Although identification of the optimal screening threshold requires a systematic evaluation of the benefits and harms of screening, the broad application of the currently recommended threshold for diabetes screening (starting at age 35 years and BMI 25 kg/m^2) in preventive medicine suggests that the benefits and harms of screening at this threshold are implicitly considered to be societally acceptable. The tradeoff between screening individuals without the disease (a false-positive result) and screening those with the disease (a true-positive result) at a given threshold can be quantified using the threshold probability method (12, 13). The posttest probability of having the disease (in this case, the prevalence of diabetes at each BMI) quantifies the tradeoffs of using that BMI as the screening threshold. Because the prevalence of diabetes is higher in persons from racial/ethnic minority groups than in White persons with a similar BMI, it may be equitable to screen racial/ethnic minority populations starting at lower BMIs than the current threshold. Because the prevalence of diabetes increases with age and increasing BMI, we assumed that the predicted prevalence of diabetes in White Americans at a BMI of 25 kg/m^2 and age of 35 years (that is, the population with the lowest predicted prevalence of diabetes in the screening-eligible population) was the implicit, societally acceptable screening threshold at which the benefits of detecting diabetes outweigh the harms of screening. Next, for each racial/ethnic minority population, we identified the "equivalent BMI threshold" for diabetes screening, defined as the BMI at which the estimated diabetes prevalence among

35-year-old adults would be equal to that among 35-year-old White adults with a BMI of 25 kg/m^2. In secondary analyses, we used a similar approach to determine whether screening persons from racial/ethnic minority populations starting at younger ages would be equivalent to the current practice of screening adults aged 35 years at a BMI of 25 kg/m^2 in White populations.

Statistical Analysis

We followed the NHANES analytic and reporting guidelines (9). Survey sample weights were used to compute nationally representative estimates. The prevalence of diabetes for Asian Americans, Black Americans, and Hispanic Americans was compared with that for White Americans in adults aged 35 to 70 years using a logistic regression model, accounting for the survey weights. Because the purpose of this analysis was to produce nationally representative estimates of prevalence in demographic groups, we did not adjust for baseline differences in age, sex, or other clinical characteristics. The data contained no missing responses for age or race/ethnicity. Individuals with missing BMI data (1.2% of our study cohort) or hemoglobin A_{1c} values (4.7% of our study cohort) were excluded. Estimates for underweight persons were not reported separately because of insufficient sample size for racial/ethnic groups. An identical approach was used to compare the prevalence of undiagnosed diabetes among major racial/ethnic groups.

To estimate the prevalence of diabetes at specific ages and BMIs, we fitted a logistic regression model with the presence or absence of diabetes as the dependent variable and BMI, race/ethnicity, and age as independent variables. In the model, we excluded adults with extreme BMIs—that is, less than 15 kg/m^2 or greater than 50 kg/m^2 (n = 310). The initial model included higher-order terms for BMI and age, as well as all possible interaction terms among all of the independent variables. Starting from this full model, we used a backward feature selection process detailed in the **Supplement** to determine the final model (see the **Supplement** for additional statistical methods). We used this model to estimate the prevalence of diabetes among White Americans with a BMI of 25 kg/m^2 and age of 35 years. We then computed, in each minority racial/ethnic group, the BMI at which the prevalence of diabetes at age 35 years would be equal to that among 35-year-old White Americans with a BMI of 25 kg/m^2 (the point estimate as well as a range that accounted for uncertainty in the estimated diabetes prevalence for both the White population and the minority population under consideration; see the **Supplement** for additional details). The thresholds were rounded down to the nearest whole number for ease of implementation, with the exception of estimates between 18.5 and 19.0 kg/m^2, which were rounded to 18.5 kg/m^2 to be consistent with CDC weight categories. In cases where the projected equivalent threshold was less than 18.5 kg/m^2, we do not report the specific threshold because of the small sample sizes at BMIs below this value.

In secondary analyses, we then determined the age at which the prevalence of diabetes at a BMI of 25 kg/m^2 in each racial/ethnic group would be equal to that among 35-year-old White Americans with a BMI of 25 kg/m^2 (the point estimate as well as a range; see the **Supplement** for additional details). Thresholds were rounded down to the nearest whole number age for ease of implementation. Age thresholds less than 18 years were reported as "less than 18 years."

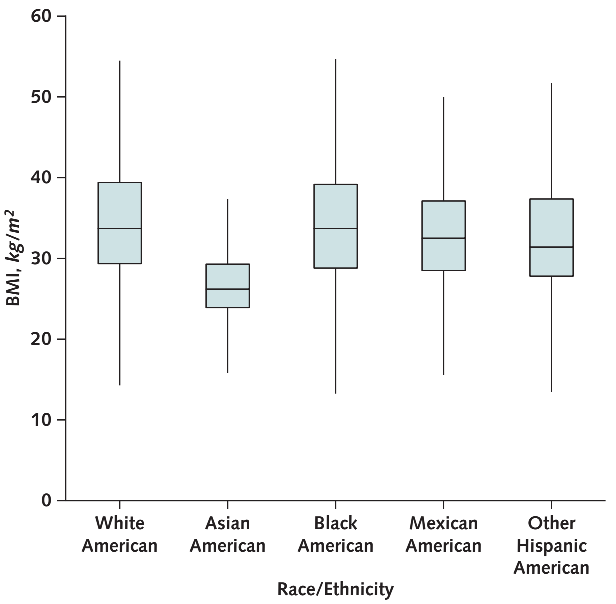
All analyses were done using SAS software, version 9.4 (SAS Institute), and R statistical computing software, version 3.5.2 (R Foundation) (14, 15).

Table 1. Demographic and Clinical Characteristics of the Study Cohort*

Characteristic	White American (n = 6319)	Asian American (n = 2658)	Black American (n = 4597)	Mexican American (n = 2884)	Other Hispanic American (n = 2114)
Projected U.S. adults (95% CI), n	131 061 575 (118 071 902–144 051 248)	12 019 291 (10 084 041–13 954 541)	24 880 636 (21 413 121–28 348 151)	20 060 495 (16 289 239–23 831 751)	14 210 314 (11 862 888–16 557 740)
Women (95% CI), %	51.3 (49.8-52.7)	54.9 (53.2–56.7)	55.3 (53.9–56.7)	48.8 (46.4–51.2)	52.4 (49.9–55.0)
Mean age (95% CI), y	44.9 (44.2–45.6)	41.8 (41.0–42.6)	41.7 (41.0–42.5)	38.4 (37.7–39.1)	40.1 (39.3–41.0)
Mean BMI (95% CI), kg/m^2	29.1 (28.8–29.4)	25.1 (24.9–25.3)	30.9 (30.6–31.2)	30.5 (30.1–30.8)	29.2 (28.8–29.6)
Diabetes prevalence (95% CI), %	9.1 (8.3–10.0)	11.9 (10.6–13.1)	14.3 (13.0–15.7)	12.8 (11.1–14.4)	10.7 (9.2–12.2)
Mean hemoglobin A_{1c} level (95% CI), %	5.5 (5.5–5.6)	5.7 (5.6–5.7)	5.8 (5.8–5.9)	5.7 (5.7–5.8)	5.7 (5.6–5.7)
Mean systolic blood pressure (95% CI), *mm Hg*	120.2 (119.7–120.7)	118.9 (118.1–119.6)	125.1 (124.4–125.8)	119.5 (118.9–120.2)	119.6 (118.7–120.6)
Mean diastolic blood pressure (95% CI), *mm Hg*	71.7 (71.1–72.3)	72.4 (71.9–72.8)	72.2 (71.6–72.9)	70.3 (69.8–70.7)	70.2 (69.1–71.3)
Mean waist circumference (95% CI), *cm*	99.8 (99.1–100.6)	88.3 (87.7–88.8)	100.2 (99.4–100.9)	100.5 (99.8–101.3)	97.3 (96.3–98.3)
Mean total cholesterol level (95% CI)					
mmol/L	4.97 (4.93–5.02)	4.95 (4.90–5.00)	4.78 (4.73–4.83)	4.90 (4.84–4.95)	4.92 (4.85–4.99)
mg/dL	192.3 (190.6–194.1)	191.4 (189.4–193.4)	184.8 (183.1–186.6)	189.4 (187.3–191.5)	190.2 (187.5–192.8)

BMI = body mass index.
* There were 19 335 nonpregnant U.S. adults aged 18–70 y in the 2011–2018 cycles of NHANES (National Health and Nutrition Examination Survey). Race/ethnicity, gender, and age were determined by self-report. Body measurements and blood pressure were determined by physical examination. Cholesterol and hemoglobin A_{1c} levels were determined by laboratory measurement. Estimates for adults who identified as other races/ethnicities by self-report are not shown (n = 763). Survey weights were used to produce nationally representative estimates.

Figure 1. BMI among U.S. adults with diabetes, stratified by race/ethnicity.



The figure shows BMI distribution by race/ethnicity in nonpregnant U.S. adults aged 35–70 y with diabetes as estimated from NHANES (National Health and Nutrition Examination Survey) (2011–2018). Median BMIs for persons with diabetes were 33.7 kg/m^2 for White Americans, 26.2 kg/m^2 for Asian Americans, 33.7 kg/m^2 for Black Americans, 32.5 kg/m^2 for Mexican Americans, and 31.4 kg/m^2 for other Hispanic Americans. The IQR is represented by the height of each box. The whiskers represent the range after exclusion of outliers using the Tukey exclusion method (16). BMI = body mass index.

Role of the Funding Source

This study was supported by institutional funds from the Richard A. and Susan F. Smith Center for Outcomes Research in Cardiology. Authors from the center participated in the design, conduct, and analysis of the study and in the decision to submit the manuscript for publication.

RESULTS

Prevalence of Diabetes and Undiagnosed Diabetes, by BMI Category

Table 1 shows key demographic and clinical characteristics of nonpregnant U.S. adults aged 18 to 70 years (the entire cohort included in this analysis), whereas the equivalent information for adults aged 35 to 70 years (the age group currently eligible for diabetes screening) is shown in Supplement Table 1 (available at Annals.org). Among U.S. adults aged 35 to 70 years, 12.4% of White Americans had diabetes, compared with 17.3% of Asian Americans (odds ratio [OR], 1.51 [95% CI, 1.27 to 1.80] for comparison with White Americans), 20.7% of Black Americans (OR, 1.85 [CI, 1.61 to 2.12]), 20.6% of Mexican Americans (OR, 1.80 [CI, 1.45 to 2.22]), and 16.4% of other Hispanic Americans (OR, 1.37 [CI, 1.14 to 1.64]).

Figure 1 shows the observed BMI distribution of U.S. adults aged 35 to 70 years with diabetes. We noted significant differences in diabetes prevalence by racial/ethnic group among persons with normal weight (that is, a BMI of 18.5 to 24.9 kg/m^2). In this group, 3.5% of White Americans had diabetes, compared with 13.0% of Asian Americans (OR, 4.14 [CI, 2.49 to 6.88]), 10.0% of Black Americans (OR, 3.07 [CI, 1.87 to 5.04]), 12.2% of Mexican Americans (OR, 3.86 [CI, 2.10 to 7.08]), and 7.0% of other Hispanic Americans (OR, 2.09 [CI, 1.20 to 3.65]) (Figure 2). Crude diabetes rates by BMI and age are presented in Supplement Tables 2 and 3 (available at Annals.org).

Rates of undiagnosed diabetes were also higher in all racial/ethnic minority Americans than in White Americans: 12.5% in White Americans compared with 27.6% in Asian Americans (OR, 2.61 [CI, 1.71 to 4.00] for comparison with White Americans), 22.8% in Black Americans (OR, 2.02 [CI, 1.42 to 2.88]), 21.2% in Mexican Americans (OR, 1.81 [CI, 1.25 to 2.62]), and 23.5% in other Hispanic Americans (OR, 2.19 [CI, 1.37 to 3.49]).

Results of additional analyses that estimated diabetes prevalence in subgroups and used alternative outcomes are presented in Supplement Figures 1 to 4 (available at Annals.org).

Equivalent BMI Threshold for Diabetes Screening

The predicted prevalence of diabetes in 35-year-old White Americans with a BMI of 25 kg/m^2 was 1.4% (CI, 1.0% to 2.0%). By comparison, 35-year-olds from each racial/ethnic minority group had a significantly higher prevalence of diabetes at this BMI, with Asian Americans at 3.8% (CI, 2.8% to 5.1%), Black Americans at 3.5% (CI, 2.7% to 4.7%), and Hispanic Americans at 3.0% (CI, 2.1% to 4.2%). Assuming that the prevalence of diabetes in 35-year-old White Americans with a BMI of 25 kg/m^2 reflects the implicit societal standard for diabetes screening, the equivalent BMI thresholds for screening are estimated to be 20 kg/m^2 (range, <18.5 to 23 kg/m^2) for Asian Americans, less than 18.5 kg/m^2 (range, <18.5 to 23 kg/m^2) for Black Americans, and 18.5 kg/m^2 (range, <18.5 to 24 kg/m^2) for Hispanic Americans (Table 2).

Equivalent Age Threshold for Diabetes Screening

In secondary analyses, assuming that the prevalence of diabetes for White adults with a BMI of 25 kg/m^2 and age of 35 years represents the implicit societal standard for diabetes screening, the equivalent age thresholds for diabetes screening among individuals with a BMI of 25 kg/m^2 from racial/ethnic minority populations were 23 years (range, <18 to 31 years) for Asian Americans, 21 years (range, <18 to 31 years) for Black Americans, and 25 years (range, <18 to 34 years) for Hispanic Americans (Table 3).

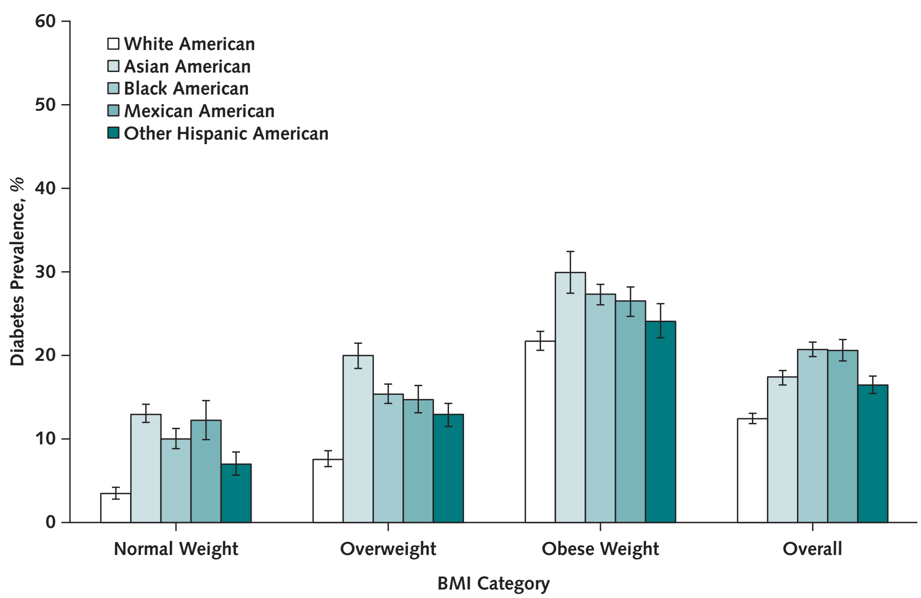
DISCUSSION

Among U.S. adults aged 35 to 70 years, Asian Americans, Black Americans, and Hispanic Americans have significantly higher rates of diagnosed and undiagnosed diabetes than White Americans. This is particularly true in adults with normal weight, among whom the prevalence of diabetes is 2 to 4 times higher in racial/ethnic minority populations than in White populations. Assuming that screening-related tradeoffs at the current screening threshold in White populations (age 35 years and BMI 25 kg/m^2) are considered societally acceptable, the equivalent BMI threshold for diabetes screening is significantly lower in racial/ethnic minority populations. Among U.S. adults aged 35 years or older, offering diabetes screening to Black Americans and Hispanic Americans with a BMI of 18.5 kg/m^2 or greater and Asian Americans with a BMI of 20 kg/m^2 or greater would be equivalent to screening White adults with a BMI of 25 kg/m^2 or greater. Alternatively, our secondary analyses suggest that Asian, Black, and Hispanic Americans with overweight or obese weight could be considered for screening at younger ages.

The American Diabetes Association recommends that diabetes screening be offered to all Asian American adults with a BMI of 23 kg/m^2 or higher (3, 7), and the 2021 USPSTF recommendations identify some racial/ethnic groups to be considered for screening at a lower age or BMI (5). However, to our knowledge, this is the first systematic analysis to identify equivalent BMI thresholds for diabetes screening in racial/ethnic minority populations. Our analysis considers only first-time screening (repeated screening may identify fewer persons with diabetes because those diagnosed during the first round of screening would be excluded), but it offers a more granular, risk-based approach to screening than the one-size-fits-all approach of current screening practices. Because of the substantial differences in diabetes rates by BMI and age among major racial/ethnic populations in the United States, uniform application of a single threshold across all groups would be inequitable, relatively overscreening White Americans while underscreening Asian, Black, and Hispanic Americans. In light of these findings, the implementation of the 2021 USPSTF recommendations to offer diabetes screening to adults with overweight or obese weight starting at age 35 years (compared with 40 years in the prior 2015 recommendations) is likely to increase the number of Asian, Black, and Hispanic Americans exposed to diabetes screening, identifying many cases of diabetes that may otherwise have been missed (5). Yet, using a single BMI threshold to determine eligibility for screening in all U.S. adults may contribute to the substantial racial/ethnic disparities in diabetes diagnosis in the United States. Our findings build on the USPSTF recommendations to lower the BMI threshold for screening Asian, Black, and Hispanic Americans (5, 17).

Our analysis adopts a comparative rather than a normative approach to diabetes screening practices in major

Figure 2. Prevalence of diabetes among U.S. adults, by race/ethnicity and BMI category.



Odds Ratio (95% CI)	Normal Weight	Overweight	Obese Weight	Overall
White American	Reference	Reference	Reference	Reference
Asian American	4.14 (2.49–6.88)	3.04 (2.18–4.23)	1.54 (1.18–2.01)	1.51 (1.27–1.80)
Black American	3.07 (1.87–5.04)	2.22 (1.65–2.97)	1.35 (1.14–1.61)	1.85 (1.61–2.12)
Mexican American	3.86 (2.10–7.08)	2.10 (1.40–3.14)	1.30 (1.02–1.66)	1.80 (1.45–2.22)
Other Hispanic American	2.09 (1.20–3.65)	1.80 (1.25–2.58)	1.15 (0.90–1.47)	1.37 (1.14–1.64)

The analysis included 12 921 nonpregnant U.S. adults aged 35–70 y in the 2011–2018 cycles of NHANES (National Health and Nutrition Examination Survey). Diabetes was defined as a hemoglobin A1c level ≥6.5% or a report of physician-diagnosed diabetes. BMIs were categorized into normal weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obese weight (≥30 kg/m^2). Underweight individuals (BMI <18.5 kg/m^2) were not reported separately because of insufficient sample size but were included in the "overall" category. Race/ethnicity was based on self-report. All estimates were appropriately weighted to account for the complex survey design and are therefore representative of the U.S. population. Prevalence is presented as the proportion of persons with diabetes within racial/ethnic groups (with 95% CIs). Odds ratios are presented in comparison with White Americans. Details of the statistical models, including baseline coefficients, are presented in the Supplement (available at Annals.org).

Table 2. Diabetes Prevalence Among U.S. Adults at Age 35 Years, by BMI: Regression Estimates*

BMI, *kg/m²*	Predicted Prevalence (95% CI), %			
	White American	Asian American	Black American	Hispanic American
25 (comparator)	1.38 (0.98–1.95)	3.77 (2.77–5.10)	3.54 (2.68–4.65)	2.97 (2.08–4.22)
24	1.16 (0.78–1.71)	3.02 (2.16–4.21)	3.12 (2.29–4.24)	2.63 (1.77–3.91)
23	0.96 (0.61–1.50)	2.39 (1.64–3.47)	2.74 (1.93–3.87)	2.33 (1.49–3.63)
22	0.79 (0.47–1.32)	1.86 (1.22–2.84)	2.39 (1.62–3.53)	2.06 (1.25–3.38)
21	0.65 (0.36–1.16)	1.43 (0.88–2.32)	2.08 (1.34–3.22)	1.81 (1.04–3.15)
20	0.53 (0.27–1.01)	1.09 (0.62–1.89)	1.80 (1.10–2.93)	1.59 (0.85–2.95)
19	0.43 (0.20–0.89)	0.81 (0.43–1.54)	1.55 (0.89–2.67)	1.39 (0.70–2.77)
18.5	0.38 (0.17–0.83)	0.70 (0.35–1.38)	1.43 (0.80–2.55)	1.30 (0.63–2.68)

BMI = body mass index.

* Regression estimates of national prevalence rates of diabetes among 35-year-old U.S. adults based on data from the 2011–2018 cycles of NHANES (National Health and Nutrition Examination Survey). A regression model was used to improve precision in estimates. Diabetes prevalence increases with BMI in each of the major race/ethnicity groups. Estimates for individuals of other races/ethnicities were not reported because of lack of more granular race/ethnicity data. Further details regarding the methodology are available in the Statistical Analysis section. We defined the equivalent BMI threshold for each racial/ethnic minority group as the BMI at which the prevalence of diabetes in 35-year-old individuals was equal to that in 35-year-old White adults at a BMI of 25 kg/m^2.

racial/ethnic groups in the United States. We identified screening thresholds in racial/ethnic minority populations that are equivalent to the current practice recommendations in White Americans, but we did not explicitly examine whether the thresholds are optimal in any of the groups studied. Such an evaluation would have to systematically consider the long-term benefits, harms, and costs of various screening strategies. For such health conditions as diabetes, for which screening tests are accurate, inexpensive, and relatively harmless and the consequences of delayed diagnosis may be catastrophic, screening protocols are typically designed to be highly sensitive rather than specific. Thus, the implicit screening threshold identified in this study (that is, a diabetes prevalence of 1.4%) may be reasonable, although empirical evidence in support of a specific threshold like this is scarce. Future studies should investigate the cost-effectiveness of various screening strategies for diabetes, including expanded, early, or repeated screening in high-risk populations. However, the incorporation of equity considerations into guidelines should not be deferred until more thorough data are available. A risk-based approach has long been the norm in cancer screening, where individuals at increased risk based on a family or personal history are recommended for early or more frequent screening (18). We make a similar argument for diabetes screening: Higher-risk populations should be screened starting at lower BMIs or younger ages. Because real-world clinical practice is heavily influenced by recommendations that are linked to insurance reimbursements, making screening recommendations more equitable should be a priority.

The use of racialized health data is a “two-edged sword”: Although racialized data have historically been used to justify and sustain hierarchical discrimination, race/ethnicity–blind approaches can enable the persistence of inequitable health care (19, 20). Not using data that account for race/ethnicity can be particularly problematic when disease prevalence and health outcomes vary substantially among racial/ethnic groups, yet universal recommendations are anchored in limited data from diverse populations. The inclusion of race and ethnicity in risk models may be appropriate if this would result in improved health outcomes and reduced health disparities (5, 20, 21). Using thresholds specific to race/ethnicity for diabetes screening has the potential to reduce disparities in diagnosis. Because implementation of screening guidelines is less consistent in racial/ethnic minority groups (22), one way to simplify use of these thresholds may be to offer diabetes screening to all adults from racial/ethnic minority populations with normal weight, overweight, and obese weight, especially because our findings suggest that each studied racial/ethnic minority group could benefit from a lower BMI threshold.

Although the disproportionate burden of diabetes in Asian, Black, and Hispanic populations compared with White populations at similar BMIs has been previously described (23–27), the physiologic and social mechanisms underlying the increased risk are less well understood. Differences in diabetes prevalence despite similar BMI may be related to variations in stress exposure and insulin sensitivity, which has been previously described among Asian, Black, and Hispanic populations (28–30). Differences in fat distribution may also contribute metabolic differences: After adjustment for BMI, Asian Americans have greater waist-to-hip ratios and more abdominal fat than White Americans (7). **Figure 2** shows that among adults with normal weight, Black, Hispanic, and Asian Americans have higher rates of diabetes than White Americans, partially supporting the notion that biological or societal factors may be contributing to differential risk. Of note, differences in diabetes within the same BMI category cannot be attributed to differences in the prevalence of type 1 diabetes because type 1 diabetes occurs at higher rates in White populations than in racial/ethnic minority populations (31).

The observed disparities in BMI by race/ethnicity (**Figure 1**) may also be the result of long-standing structural racism. For instance, structural barriers to accessing high-quality food or safe physical activity—both critical to preventing diabetes—disproportionately affect racial/ethnic minority populations (32). Structural barriers to accessing prevention, screening, and treatment—such as lower rates of health insurance, challenges with obtaining transportation to care, limited access to primary care providers and specialists, and discrimination and bias within the health care system—also exacerbate stress and increase racial/ethnic disparities in diabetes prevalence and outcomes (33, 34). For instance, differential access to evidence-based prevention strategies may increase disease progression from prediabetes to diabetes, leading to higher rates of observed diabetes in racial/ethnic minority populations than in White populations within similar BMI categories.

Our study has a few limitations. Our analysis adheres to the demographic taxonomy used by NHANES, which does not fully capture contemporary and evolving concepts of race, ethnicity, and ancestry (20). We could not examine racial/ethnic subpopulations because of sample size considerations, although substantial genetic, dietary, and acculturation differences may exist within racial/ethnic groups. For instance, Mexican and Puerto Rican Americans have the highest diabetes prevalence among Latinx American populations (35), and East Asian and South Asian Americans have the highest prevalence among Asian Americans (35). Although the American Diabetes Association has called for further studies examining heterogeneity in diabetes risk among subpopulations, they have also previously stated that holding off on recommending a specific (lower) screening threshold until additional data for subgroups are available could be detrimental to minority population health (7, 23). Our study was based on survey data and is therefore susceptible to response bias, but our use of laboratory and physical examination measurements reduces this bias. We did not examine the role of other measures of adiposity (such as waist-to-hip ratio) or other diagnostic tests of impaired glucose tolerance. Because our objective was to inform generalizable screening recommendations, we focused on measures commonly used in contemporary screening practice. Minor differences in the observed prevalence estimates (from NHANES) and regression-based prevalence estimates likely reflect the imprecision resulting from sample size limitations, particularly for racial/ethnic minority populations. When estimating equivalent screening thresholds, our analysis accounted for imprecision in diabetes prevalence estimates for both White and racial/ethnic minority populations. With this approach, the estimated BMI thresholds for diabetes screening were 20 kg/m^2 for Asian Americans, less than 18.5 kg/m^2 for Black Americans, and 18.5 kg/m^2 for Hispanic Americans, but we acknowledge the uncertainty in these estimates (for example, the upper bound was as high as 24 kg/m^2 in Hispanic Americans and 23 kg/m^2 in Asian and Black Americans). The cross-sectional nature of this analysis precludes examination of repeated screening strategies. If expanded screening is adopted with fidelity and newly identified patients with prediabetes and diabetes receive evidence-based interventions to prevent progression of disease, this would by design reduce the number of patients with undiagnosed cases who would benefit from future screening. Future screening recommendations should therefore be adapted to the changes in the epidemiology of diabetes and prediabetes that result from expansion of screening eligibility.

Table 3. Diabetes Prevalence Among U.S. Adults at BMI 25 kg/m^2, by Age: Regression Estimates*

Age, y	Predicted Prevalence (95% CI), %			
	White American	Asian American	Black American	Hispanic American
40	1.92 (1.43–2.58)	5.77 (4.53–7.33)	5.00 (3.95–6.31)	4.43 (3.27–5.97)
39	1.80 (1.33–2.44)	5.30 (4.11–6.82)	4.67 (3.66–5.94)	4.09 (2.99–5.57)
38	1.69 (1.23–2.30)	4.87 (3.73–6.35)	4.36 (3.39–5.59)	3.77 (2.73–5.19)
37	1.58 (1.14–2.18)	4.47 (3.38–5.90)	4.06 (3.13–5.26)	3.48 (2.50–4.85)
36	1.48 (1.06–2.06)	4.10 (3.06–5.49)	3.79 (2.90–4.95)	3.22 (2.28–4.52)
35 (comparator)	1.38 (0.98–1.95)	3.77 (2.77–5.10)	3.54 (2.68–4.65)	2.97 (2.08–4.22)
34	1.30 (0.91–1.85)	3.45 (2.51–4.75)	3.30 (2.47–4.38)	2.74 (1.90–3.93)
33	1.21 (0.84–1.75)	3.17 (2.27–4.41)	3.07 (2.29–4.12)	2.53 (1.73–3.67)
32	1.14 (0.78–1.66)	2.90 (2.05–4.10)	2.86 (2.11–3.87)	2.33 (1.58–3.42)
31	1.06 (0.72–1.57)	2.66 (1.85–3.81)	2.67 (1.95–3.64)	2.15 (1.44–3.19)
30	1.00 (0.67–1.49)	2.44 (1.68–3.54)	2.49 (1.80–3.42)	1.98 (1.32–2.97)
29	0.93 (0.62–1.41)	2.23 (1.51–3.29)	2.32 (1.66–3.22)	1.83 (1.20–2.77)
28	0.87 (0.57–1.33)	2.05 (1.37–3.05)	2.16 (1.54–3.03)	1.68 (1.09–2.58)
27	0.82 (0.53–1.26)	1.87 (1.24–2.84)	2.01 (1.42–2.84)	1.55 (1.00–2.41)
26	0.76 (0.49–1.20)	1.72 (1.12–2.63)	1.87 (1.31–2.67)	1.43 (0.91–2.24)
25	0.72 (0.45–1.13)	1.57 (1.01–2.45)	1.74 (1.21–2.51)	1.32 (0.83–2.09)
24	0.67 (0.42–1.07)	1.44 (0.91–2.27)	1.62 (1.12–2.36)	1.21 (0.75–1.95)
23	0.63 (0.39–1.02)	1.32 (0.82–2.11)	1.51 (1.03–2.22)	1.12 (0.69–1.82)
22	0.59 (0.36–0.96)	1.21 (0.74–1.96)	1.41 (0.95–2.09)	1.03 (0.63–1.69)
21	0.55 (0.33–0.91)	1.10 (0.67–1.82)	1.31 (0.88–1.96)	0.95 (0.57–1.58)
20	0.51 (0.30–0.87)	1.01 (0.60–1.69)	1.22 (0.81–1.84)	0.87 (0.52–1.47)

BMI = body mass index.

* Estimated prevalence of diabetes by age among nonpregnant U.S. adults with a BMI of 25 kg/m^2 based on a logistic regression model using data from the 2011–2018 cycles of NHANES (National Health and Nutrition Examination Survey). Regression modeling was used to improve precision of the prevalence estimates (compared with direct estimation from NHANES observations). At age 35 y (the starting age of the current screening recommendations by the U.S. Preventive Services Task Force), the prevalence of diabetes in racial/ethnic minority populations is substantially higher than that in White populations. The equivalent age threshold for each racial/ethnic minority group was defined as the age at which the prevalence of diabetes in individuals with a BMI of 25 kg/m^2 was equal to that in 35-year-old White adults at a BMI of 25 kg/m^2. Additional methodological details are presented in the Statistical Analysis section and in the Supplement (available at Annals.org).

In conclusion, among U.S. adults aged 35 to 70 years with normal weight, rates of diabetes and undiagnosed diabetes are significantly higher in Asian Americans, Black Americans, and Hispanic Americans than in White Americans. Among U.S. adults aged 35 years or older, offering diabetes screening to Black Americans and Hispanic Americans with a BMI of 18.5 kg/m^2 or greater and Asian Americans with a BMI of 20 kg/m^2 or greater would be equivalent to screening White adults with a BMI of 25 kg/m^2 or greater. Future studies should examine the health effect and cost-effectiveness of implementing screening thresholds specific to race/ethnicity to reduce disparities in diabetes diagnosis.

From Richard A. and Susan F. Smith Center for Outcomes Research in Cardiology, Division of Cardiology, Beth Israel Deaconess Medical Center, and Harvard Medical School, Boston, Massachusetts (R.A., R.W.Y., N.C., R.K.W., D.S.K.); Department of Epidemiology and Biostatistics, University of California, San Francisco, San Francisco, California (K.B.); Harvard Medical School, Boston, Massachusetts (Y.S.); and Richard A. and Susan F. Smith Center for Outcomes Research in Cardiology, Division of Cardiology, Beth Israel Deaconess Medical Center, Boston, Massachusetts (C.S.).

Financial Support: By institutional funds from the Richard A. and Susan F. Smith Center for Outcomes Research in Cardiology.

Disclosures: Disclosures can be viewed at www.acponline.org/authors/icmje/ConflictOfInterestForms.do?msNum=M20-8079.

Reproducible Research Statement: *Study protocol:* Not available. *Statistical code:* Available on request from Dr. Kazi (e-mail, dkazi@bidmc.harvard.edu). *Data set:* Publicly available from the CDC.

Corresponding Author: Dhruv S. Kazi, MD, MSc, MS, Smith Center for Outcomes Research, 375 Longwood Avenue, 4th Floor, Boston, MA 02215; e-mail, dkazi@bidmc.harvard.edu.

Author contributions are available at Annals.org.

References

1. Centers for Disease Control and Prevention. National Diabetes Statistics Report 2020: estimates of diabetes and its burden in the United States. 2020.
2. American Diabetes Association. Economic costs of diabetes in the U.S. in 2017. Diabetes Care. 2018;41:917-928. [PMID: 29567642] doi:10.2337/dci18-0007
3. American Diabetes Association. 2. Classification and diagnosis of diabetes: Standards of Medical Care in Diabetes—2020. Diabetes Care. 2020;43:S14-S31. [PMID: 31862745] doi:10.2337/dc20-S002
4. U.S. Preventive Services Task Force. Final recommendation statement. Abnormal blood glucose and type 2 diabetes mellitus: screening. 26 October 2015. Accessed at www.uspreventiveservicestaskforce.org/uspstf/recommendation/screening-for-abnormal-blood-glucose-and-type-2-diabetes-october-2015 on 7 September 2020.
5. Davidson KW, Barry MJ, Mangione CM, et al; US Preventive Services Task Force. Screening for prediabetes and type 2 diabetes: US Preventive Services Task Force recommendation statement. JAMA. 2021;326:736-743. [PMID: 34427594] doi:10.1001/jama.2021.12531
6. Kaiser Family Foundation. Number of diabetes deaths per 100,000 population by race/ethnicity. 2019. Accessed at www.kff.org/other/state-indicator/diabetes-death-rate-by-raceethnicity on 17 June 2021.
7. Hsu WC, Araneta MR, Kanaya AM, et al. BMI cut points to identify at-risk Asian Americans for type 2 diabetes screening. Diabetes Care. 2015;38:150-8. [PMID: 25538311] doi:10.2337/dc14-2391
8. Doubeni CA, Simon M, Krist AH. Addressing systemic racism through clinical preventive service recommendations from the US Preventive Services Task Force. JAMA. 2021;325:627-628. [PMID: 33492333] doi:10.1001/jama.2020.26188
9. National Center for Health Statistics; Centers for Disease Control and Prevention. NHANES Survey Methods and Analytic Guidelines. 2020. Accessed at wwwn.cdc.gov/nchs/nhanes/analyticguidelines.aspx#analytic-guidelines on 1 July 2020.
10. Menke A, Casagrande S, Geiss L, et al. Prevalence of and trends in diabetes among adults in the United States, 1988-2012. JAMA. 2015;314:1021-9. [PMID: 26348752] doi:10.1001/jama.2015.10029
11. Centers for Disease Control and Prevention. All about adult BMI. 2020. Accessed at www.cdc.gov/healthyweight/assessing/bmi/adult_bmi/index.html on 7 September 2021.
12. Newman TB, Kohn MA. Evidence-Based Diagnosis. Cambridge Univ Pr; 2009.
13. Weatherall M. Information provided by diagnostic and screening tests: improving probabilities. Postgrad Med J. 2018;94:230-235. [PMID: 29133377] doi:10.1136/postgradmedj-2017-135273
14. SAS. Version 9.4. SAS Institute; 2021.
15. R: A Language and Environment for Statistical Computing. Version 3.5.2. R Foundation for Statistical Computing; 2018. Accessed at www.R-project.org on 1 August 2020.
16. Seo S. A Review and Comparison of Methods for Detecting Outliers in Univariate Data Sets. University of Pittsburgh; 2006. Accessed at http://d-scholarship.pitt.edu/7948 on 16 December 2020.
17. U.S. Preventive Services Task Force. Final recommendation statement. Prediabetes and type 2 diabetes: screening. 24 August 2021. Accessed at www.uspreventiveservicestaskforce.org/uspstf/recommendation/screening-for-prediabetes-and-type-2-diabetes on 5 April 2022.
18. Davidson KW, Barry MJ, Mangione CM, et al; US Preventive Services Task Force. Screening for colorectal cancer: US Preventive Services Task Force recommendation statement. JAMA. 2021;325:1965-1977. [PMID: 34003218] doi:10.1001/jama.2021.6238
19. Krieger N. Structural racism, health inequities, and the two-edged sword of data: structural problems require structural solutions. Front Public Health. 2021;9:655447. [PMID: 33937178] doi:10.3389/fpubh.2021.655447
20. Borrell LN, Elhawary JR, Fuentes-Afflick E, et al. Race and genetic ancestry in medicine – a time for reckoning with racism. N Engl J Med. 2021;384:474-480. [PMID: 33406325] doi:10.1056/NEJMms2029562
21. Bibbins-Domingo K, Whitlock E, Wolff T, et al. Developing recommendations for evidence-based clinical preventive services for diverse populations: methods of the U.S. Preventive Services Task Force. Ann Intern Med. 2017;166:565-571. [PMID: 28265649] doi:10.7326/M16-2656
22. Tung EL, Baig AA, Huang ES, et al. Racial and ethnic disparities in diabetes screening between Asian Americans and other adults: BRFSS 2012-2014. J Gen Intern Med. 2017;32:423-429. [PMID: 27848187] doi:10.1007/s11606-016-3913-x
23. Araneta MR, Kanaya AM, Hsu WC, et al. Optimum BMI cut points to screen Asian Americans for type 2 diabetes. Diabetes Care. 2015;38:814-20. [PMID: 25665815] doi:10.2337/dc14-2071
24. Zhu Y, Sidell MA, Arterburn D, et al. Racial/ethnic disparities in the prevalence of diabetes and prediabetes by BMI: Patient Outcomes Research to Advance Learning (PORTAL) multisite cohort of adults in the U.S. Diabetes Care. 2019;42:2211-2219. [PMID: 31537541] doi:10.2337/dc19-0532

25. **Maskarinec G, Grandinetti A, Matsuura G, et al.** Diabetes prevalence and body mass index differ by ethnicity: the Multiethnic Cohort. Ethn Dis. 2009;19:49-55. [PMID: 19341163]
26. **Shai I, Jiang R, Manson JE, et al.** Ethnicity, obesity, and risk of type 2 diabetes in women: a 20-year follow-up study. Diabetes Care. 2006;29:1585-90. [PMID: 16801583]
27. **Teufel F, Seiglie JA, Geldsetzer P, et al.** Body-mass index and diabetes risk in 57 low-income and middle-income countries: a cross-sectional study of nationally representative, individual-level data in 685 616 adults. Lancet. 2021;398:238-248. [PMID: 34274065] doi:10.1016/S0140-6736(21)00844-8
28. **Gower BA, Fernández JR, Beasley TM, et al.** Using genetic admixture to explain racial differences in insulin-related phenotypes. Diabetes. 2003;52:1047-51. [PMID: 12663479]
29. **Kodama K, Tojjar D, Yamada S, et al.** Ethnic differences in the relationship between insulin sensitivity and insulin response: a systematic review and meta-analysis. Diabetes Care. 2013;36:1789-96. [PMID: 23704681] doi:10.2337/dc12-1235
30. **Qu HQ, Li Q, Lu Y, et al.** Ancestral effect on HOMA-IR levels quantitated in an American population of Mexican origin. Diabetes Care. 2012;35:2591-3. [PMID: 22891255] doi:10.2337/dc12-0636
31. **Spanakis EK, Golden SH.** Race/ethnic difference in diabetes and diabetic complications. Curr Diab Rep. 2013;13:814-23. [PMID: 24037313] doi:10.1007/s11892-013-0421-9
32. **Franz MJ.** Weight management: obesity to diabetes. Diabetes Spectr. 2017;30:149-153. [PMID: 28848305] doi:10.2337/ds17-0011
33. **Palaniappan LP, Araneta MR, Assimes TL, et al; American Heart Association Council on Epidemiology and Prevention.** Call to action: cardiovascular disease in Asian Americans: a science advisory from the American Heart Association. Circulation. 2010;122:1242-52. [PMID: 20733105] doi:10.1161/CIR.0b013e3181f22af4
34. **Carnethon MR, Pu J, Howard G, et al; American Heart Association Council on Epidemiology and Prevention; Council on Cardiovascular Disease in the Young; Council on Cardiovascular and Stroke Nursing; Council on Clinical Cardiology; Council on Functional Genomics and Translational Biology; and Stroke Council.** Cardiovascular health in African Americans: a scientific statement from the American Heart Association. Circulation. 2017;136:e393-e423. [PMID: 29061565] doi:10.1161/CIR.0000000000000534
35. **Cheng YJ, Kanaya AM, Araneta MRG, et al.** Prevalence of diabetes by race and ethnicity in the United States, 2011-2016. JAMA. 2019;322:2389-2398. [PMID: 31860047] doi:10.1001/jama.2019.19365

Author Contributions: Conception and design: R. Aggarwal, D. S. Kazi, R.K. Wadhera.
Analysis and interpretation of the data: R. Aggarwal, D.S. Kazi, C. Shen, Y. Song, R.K. Wadhera.
Drafting of the article: R. Aggarwal, N. Chiu, D.S. Kazi, C. Shen.
Critical revision for important intellectual content: R. Aggarwal, K. Bibbins-Domingo, N. Chiu, D.S. Kazi, R.K. Wadhera, R.W. Yeh.
Final approval of the article: R. Aggarwal, K. Bibbins-Domingo, N. Chiu, D.S. Kazi, C. Shen, Y. Song, R.K. Wadhera, R.W. Yeh.
Statistical expertise: R. Aggarwal, D.S. Kazi, C. Shen, Y. Song.
Obtaining of funding: D.S. Kazi.
Administrative, technical, or logistic support: D.S. Kazi.