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Prevalence of Diabetes by Race and Ethnicity in the United States, 2011-2016

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IMPORTANCE The prevalence of diabetes among Hispanic and Asian American subpopulations in the United States is unknown.

OBJECTIVE To estimate racial/ethnic differences in the prevalence of diabetes among US adults 20 years or older by major race/ethnicity groups and selected Hispanic and non-Hispanic Asian subpopulations.

DESIGN, SETTING, AND PARTICIPANTS National Health and Nutrition Examination Surveys, 2011-2016, cross-sectional samples representing the noninstitutionalized, civilian, US population. The sample included adults 20 years or older who had self-reported diagnosed diabetes during the interview or measurements of hemoglobin A_{1c} (HbA_{1c}), fasting plasma glucose (FPG), and 2-hour plasma glucose (2hPG).

EXPOSURES Race/ethnicity groups: non-Hispanic white, non-Hispanic black, Hispanic and Hispanic subgroups (Mexican, Puerto Rican, Cuban/Dominican, Central American, and South American), non-Hispanic Asian and non-Hispanic Asian subgroups (East, South, and Southeast Asian), and non-Hispanic other.

MAIN OUTCOMES AND MEASURES Diagnosed diabetes was based on self-reported prior diagnosis. Undiagnosed diabetes was defined as HbA_{1c} 6.5% or greater, FPG 126 mg/dL or greater, or 2hPG 200 mg/dL or greater in participants without diagnosed diabetes. Total diabetes was defined as diagnosed or undiagnosed diabetes.

RESULTS The study sample included 7575 US adults (mean age, 47.5 years; 52% women; 2866 [65%] non-Hispanic white, 1636 [11%] non-Hispanic black, 1952 [15%] Hispanic, 909 [6%] non-Hispanic Asian, and 212 [3%] non-Hispanic other). A total of 2266 individuals had diagnosed diabetes; 377 had undiagnosed diabetes. Weighted age- and sex-adjusted prevalence of total diabetes was 12.1% (95% CI, 11.0%-13.4%) for non-Hispanic white, 20.4% (95% CI, 18.8%-22.1%) for non-Hispanic black, 22.1% (95% CI, 19.6%-24.7%) for Hispanic, and 19.1% (95% CI, 16.0%-22.1%) for non-Hispanic Asian adults (overall $P < .001$). Among Hispanic adults, the prevalence of total diabetes was 24.6% (95% CI, 21.6%-27.6%) for Mexican, 21.7% (95% CI, 14.6%-28.8%) for Puerto Rican, 20.5% (95% CI, 13.7%-27.3%) for Cuban/Dominican, 19.3% (95% CI, 12.4%-26.1%) for Central American, and 12.3% (95% CI, 8.5%-16.2%) for South American subgroups (overall $P < .001$). Among non-Hispanic Asian adults, the prevalence of total diabetes was 14.0% (95% CI, 9.5%-18.4%) for East Asian, 23.3% (95% CI, 15.6%-30.9%) for South Asian, and 22.4% (95% CI, 15.9%-28.9%) for Southeast Asian subgroups (overall $P = .02$). The prevalence of undiagnosed diabetes was 3.9% (95% CI, 3.0%-4.8%) for non-Hispanic white, 5.2% (95% CI, 3.9%-6.4%) for non-Hispanic black, 7.5% (95% CI, 5.9%-9.1%) for Hispanic, and 7.5% (95% CI, 4.9%-10.0%) for non-Hispanic Asian adults (overall $P < .001$).

CONCLUSIONS AND RELEVANCE In this nationally representative survey of US adults from 2011 to 2016, the prevalence of diabetes and undiagnosed diabetes varied by race/ethnicity and among subgroups identified within the Hispanic and non-Hispanic Asian populations.

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The United States is an increasingly diverse nation, as Hispanic and non-Hispanic Asian individuals collectively now account for 23% of the US population—a proportion expected to increase to 38% by 2060.[1] Worldwide, both Hispanic and Asian populations have been shown to have a higher prevalence of diabetes than European and African populations in both native settings and among their diaspora.[2,3] These differences among race/ethnicity groups could emanate from multiple factors, including genetic, epigenetic, lifestyle, and environment.[4] Previous reports have documented considerable variation among Hispanic and non-Hispanic Asian subgroups in diabetes prevalence in the United States.[3,5,6] A previous population-based national study showed that Hispanic and non-Hispanic Asian populations overall had a similar prevalence of total diabetes and prediabetes compared with non-Hispanic black populations but a higher prevalence of undiagnosed diabetes.[7] To date, there have been no national estimates of diabetes and prediabetes prevalences among Hispanic or non-Hispanic Asian subgroups. The lack of nationally representative and current estimates of diabetes and prediabetes among the Hispanic and non-Hispanic Asian populations has been a gap in national surveillance.

In this study, population-based survey data from the US National Health and Nutrition Examination Survey (NHANES), 2011-2016, were used to examine the prevalence of diagnosed, undiagnosed, and total diabetes as well as prediabetes in US adults 20 years or older among major race/ethnicity groups as well as among Hispanic and non-Hispanic Asian subgroups.

Key Points

Question During 2011-2016, how prevalent was diabetes among major race/ethnicity groups and subgroups of Hispanic and non-Hispanic Asian adults in the United States?

Findings In this cross-sectional study that included 7575 adults, the age- and sex-adjusted diabetes prevalence was 12.1% for non-Hispanic white, 20.4% for non-Hispanic black, 22.1% for Hispanic, and 19.1% for non-Hispanic Asian groups. The diabetes prevalence also differed significantly among Hispanic or non-Hispanic Asian subgroups.

Meaning In the United States in 2011-2016, the prevalence of diabetes varied across racial/ethnic groups.

Methods

Data Source

The NHANES is a multistage, ongoing, complex survey to assess the health status of the noninstitutionalized civilian population in the United States, conducted by the Centers for Disease Control and Prevention (CDC) National Center for Health Statistics. The research ethics review board of the CDC approved the NHANES procedures and protocols, and all participants provided written informed consent. Participants were interviewed at home regarding demographic, socioeconomic, dietary, and health-related questions. They then visited a mobile examination center where other medical, dental, and physiological measurements and laboratory tests were performed by highly trained medical personnel.[8] NHANES data have been released in 2-year survey cycles since 1999; the dates of final collection of cycles are not publicly available. The unweighted total response rates for NHANES were 73% (2011-2012), 71% (2013-2014), and 61% (2015-2016) for the interviewed samples, and 70% (2011-2012), 69% (2013-2014), and 59% (2015-2016) for the examined samples.[9] Since 2007, NHANES has oversampled Hispanic American individuals and since 2011 has oversampled non-Hispanic Asian American individuals, providing more reliable estimates of the prevalence of diabetes among Hispanic and non-Hispanic Asian populations than previously available.[10,11]

In this study, 3 cycles of NHANES data (2011-2012, 2013-2014, and 2015-2016) were combined. All nonpregnant participants 20 years or older were eligible for this study. Among them, participants who visited the mobile examination center were eligible for measurement of glycated hemoglobin (HbA_{1c}) levels, with a subset randomly selected to attend the morning examination session for measurement of fasting plasma glucose (FPG) levels after fasting for 8 to 24 hours and 2-hour plasma glucose (2hPG) levels measured after a 75-g oral glucose challenge. Participants using medications for diabetes, those with hemophilia or receiving chemotherapy, and those who refused to participate were excluded from the FPG or 2hPG measurement. To enable nationally representative estimation, poststratification reweighting using an inverse probability weighting approach was used to account for participants excluded from the randomly selected subset with FPG and 2hPG measurements.[12] There were no missing values for age, sex, or race/ethnicity in the selected subset, and 6 participants with missing values for HbA_{1c}, FPG, or 2hPG were excluded from analyses. Participants with missing values for body mass index (BMI) in the 2hPG sample were retained for analyses not using BMI, and the complete-case approach was used for analyses using BMI. To calculate weighted nationally representative estimates, we used the interview sampling weights for participants with diagnosed diabetes and used 2hPG sampling weights for adults without diagnosed diabetes.

Outcomes

Diagnosed diabetes was defined at the interview by having a self-reported previous diabetes diagnosis other than during pregnancy made by a "doctor or health professional." To make our estimates comparable with the CDC reports,[13] FPG and 2hPG levels were calibrated to early survey cycles by using the recommended backward calibration equations.[8] Having undiagnosed diabetes was defined as a participant without self-reported diagnosed diabetes but with an HbA_{1c} level 6.5% (47.5 mmol/mol) or greater, FPG level 126 mg/dL (7.0 mmol/L) or greater, or 2hPG level 200 mg/dL (11.1 mmol/L) or greater at the examination. Total diabetes was defined as having self-reported diagnosed diabetes or undiagnosed diabetes. Prediabetes was defined in a person without total diabetes who had an HbA_{1c} of 5.7% or greater to less than 6.5%, FPG 100 mg/dL

or greater to less than 126 mg/dL, or 2hPG 140 mg/dL or greater to less than 200 mg/dL.

Definition of Race/Ethnicity Groups and Subgroups

Race/ethnicity was categorized as Hispanic or non-Hispanic at first. The non-Hispanic black category (single race or in combination with any other race including non-Hispanic Asian) included all non-Hispanic persons who self-identified as black or African American.[10,11] The non-Hispanic nonblack Asian category (single race or in combination with any other race except black, hereafter referred to as non-Hispanic Asian) included all non-Hispanic persons who did not self-identify as black and had origins in any of the Asian countries. Non-Hispanic participants not falling into those categories who were white were defined as non-Hispanic white, and other non-Hispanic participants who were not white were defined as non-Hispanic other.

Both Hispanic subgroups and non-Hispanic Asian subgroups were based on self-reported race/ethnicity origins in restricted data from the CDC Research Data Center. Hispanic participants were divided into 6 subgroups: Mexican, Puerto Rican, Cuban/Dominican, Central American (Costa Rican, Guatemalan, Honduran, Nicaraguan, Panamanian, Salvadoran, other Central American), South American (Argentinean, Bolivian, Chilean, Colombian, Ecuadorian, Paraguayan, Peruvian, Uruguayan, Venezuelan, other South American), and other Hispanic. Non-Hispanic Asian participants were divided into 4 subgroups: East Asian (Chinese, Japanese, and Korean), South Asian (Asian Indian, Pakistani, Sri Lankan, Bangladeshi, Nepali, and Bhutanese), Southeast Asian (Filipino, Vietnamese, Cambodian, Laotian, Thai, Indonesian, Malaysian, Singaporean, and Hmong), and other Asian. Estimates for other Hispanics or other Asians were not reported because of small sample sizes of mixed groups or subgroups, but the sampled adults of those race/ethnicity subgroups were included for the estimates of the overall Hispanic or overall non-Hispanic Asian populations.

Other Variables

Other self-reported demographic variables included age, sex, and education (less than high school, high school graduate or equivalent, or more than high school). Body weight was measured using a digital weight scale with participants wearing only underwear beneath the examination gown. Standing height was measured using a stadiometer with a fixed vertical backboard and adjustable headpiece. BMI was classified into 5 categories (<23.0, 23.0-24.9, 25.0-29.9, 30.0-34.9, and ≥35.0 [calculated as weight in kilograms divided by height in meters squared]).

Statistical Analysis

All analysis accounted for the complex sampling design to produce population-based weighted US nationally representative estimates according to NHANES analytic guidelines.[14] Adjusted estimates were reported for comparing among groups or among subgroups. Multiple linear regression was used to model adjusted means of continuous dependent variables. Multiple logistic regression was used to model adjusted proportions of categorical dependent variables. Mean prediction from multiple regression was used as an adjusted estimate over the covariate distribution.[15] Among adults without diagnosed or undiagnosed diabetes, the distributions of HbA_{1c} level, FPG, and 2hPG values were investigated using multiple quantile regression.

Most estimates of regression adjusted for demographic factors, including age, age squared, sex, and race/ethnicity. BMI-adjusted prevalence of diabetes was investigated in additional analyses. Variances and confidence intervals of mean or proportion were estimated using the Taylor linearization as a default. The delete-1 jackknife replicate method was used for calculating the variation of quantiles, and comparisons of estimates from different models were based on the delta method.[16]

All analyses were performed using Stata version 15.1 (StataCorp). Estimates with 95% confidence intervals that did not include the null or with a 2-tailed significance level (*P* value) less than .05 were considered statistically significant. To minimize the false-positive inference, overall *P* values among race/ethnicity groups, among Hispanic subgroups, or among non-Hispanic Asian subgroups were used instead of the *P* value of pairwise comparisons between 2 race/ethnicity groups or subgroups. Estimates noted in the tables with relative standard error (ie, standard error/estimate) less than 30% are considered unreliable and should be interpreted with caution.[17] Given the multiple outcomes and subgroup comparisons without adjustment for multiple comparisons, findings should be interpreted as exploratory.

Results

The interview sample of NHANES 2011-2016 had 16 856 men and nonpregnant women 20 years or older with (n = 2266) and without (n = 14 590) self-reported diagnosed diabetes. Among them, 16 189 participants had HbA_{1c} levels measured, 6910 had FPG levels measured, and 5315 had 2hPG levels measured after a 75-g oral glucose challenge. Results reported here were based on a sample of 7575 men and nonpregnant women either with diagnosed diabetes (n = 2266) or values for HbA_{1c}, FPG, and 2hPG (n = 5309).

The sample included 2866 (65%) non-Hispanic white, 1636 (11%) non-Hispanic black, 1952 (15%) Hispanic, 909 (6%) non-Hispanic Asian, and 212 (3%) non-Hispanic other participants. Mean age was 49.6 years for non-Hispanic white, 45.1 years for non-Hispanic black, 41.8 years for Hispanic, 44.7 years for non-Hispanic Asian, and 46.1 years for non-Hispanic other participants (**Table 1**).

Forty-seven participants with missing values for BMI in the 2hPG sample were excluded for analyses using BMI. Mean BMIs differed significantly among race/ethnicity groups and subgroups: 29.2 (95% CI, 28.8-29.6) for non-Hispanic white, 30.6 (95% CI, 30.2-31.1) for non-Hispanic black, 29.9 (95% CI, 29.5-30.4) for Hispanic, and 24.4 (95% CI, 24.0-24.7) for non-Hispanic Asian groups and subgroups (*P* < .001 overall). Among non-Hispanic Asian subgroups, mean BMIs were 23.4 (95% CI, 22.9-23.9) for East Asian, 25.9

Table 1. Weighted Characteristics of Participants 20 Years or Older by Race/Ethnicity, NHANES 2011-2016

	Mean or % (95% CI)													
					Selected Hispanic Subgroups						Selected Non-Hispanic Asian Subgroups			
	Total (n = 7575)	Non-Hispanic White (n = 2866)	Non-Hispanic Black (n = 1636)	Hispanic (n = 1952)[a]	Mexican (n = 1107)	Puerto Rican (n = 178)	Cuban/ Dominican (n = 160)	Central American (n = 187)[b]	South American (n = 164)[c]	Non-Hispanic Asian (n = 909)[a]	East Asian (n = 322)[d]	South Asian (n = 209)[e]	Southeast Asian (n = 163)[f]	Non-Hispanic Other (n = 212)
Age, mean, y	47.5 (46.8-48.3)	49.6 (48.6-50.5)	45.1 (44.1-46.0)	41.8 (40.6-42.9)	41.2 (39.4-42.9)	44.3 (40.9-47.8)	46.0 (42.5-49.4)	39.7 (37.5-41.9)	42.6 (40.1-45.1)	44.7 (43.3-46.1)	45.1 (42.9-47.4)	44.1 (41.6-46.5)	44.7 (41.7-47.7)	46.1 (42.6-49.6)
Sex, %														
Women	51.9 (50.6-53.2)	51.4 (49.6-53.2)	55.6 (52.3-58.9)	50.3 (48.1-52.4)	50.2 (47.4-53.0)	59.3 (49.4-69.2)	51.1 (39.7-62.6)	45.2 (38.7-51.7)	45.7 (37.4-53.9)	54.3 (51.6-57.0)	56.8 (52.5-61.2)	46.5 (41.2-51.9)	57.2 (50.2-64.1)	52.6 (44.6-60.6)
Men	48.1 (46.8-49.4)	48.6 (46.8-50.4)	44.4 (41.1-47.7)	49.7 (47.6-51.9)	49.8 (47.0-52.6)	40.7 (30.8-50.6)	48.9 (37.4-60.3)	54.8 (48.3-61.3)	54.3 (46.1-62.6)	45.7 (43.0-48.4)	43.2 (38.8-47.5)	53.5 (48.1-58.8)	42.8 (35.9-49.8)	47.4 (39.4-55.4)
Education, %														
<High school	16.1 (13.7-18.5)	11.1 (8.3-13.9)	17.2 (14.8-19.7)	39.5 (35.3-43.7)	46.7 (42.4-51.1)	23.2 (11.6-34.9)	25.0 (17.5-32.5)	54.8 (46.2-63.4)	15.2 (9.7-20.7)	13.4 (10.4-16.3)	9.2 (4.3-14.0)	15.4 (8.3-22.5)	22.0 (14.0-29.9)	10.7 (5.3-16.1)
High school	20.9 (18.6-23.1)	20.8 (17.5-24.0)	26.8 (24.0-29.5)	20.2 (17.4-22.9)	19.8 (15.9-23.7)	23.6 (16.0-31.2)	17.8 (11.4-24.2)	18.3 (9.7-27.0)	15.8 (9.4-22.1)	12.7 (9.6-15.8)	13.2 (8.2-18.1)	8.5 (4.3-12.6)	18.1 (9.9-26.2)	19.0 (9.6-28.4)
>High school	63.0 (59.5-66.6)	68.2 (63.2-73.1)	56.0 (52.0-59.9)	40.3 (36.1-44.5)	33.4 (28.4-38.4)	53.2 (37.4-69.0)	57.2 (49.3-65.1)	26.9 (19.0-34.7)	69.1 (60.6-77.5)	73.9 (69.4-78.5)	77.7 (70.8-84.6)	76.1 (67.7-84.5)	60.0 (48.4-71.6)	70.3 (59.0-81.5)
Weight, mean, kg	83.2 (82.3-84.1)	84.4 (83.3-85.6)	87.5 (86.5-88.6)	81.2 (79.8-82.7)	82.5 (80.8-84.2)	80.9 (77.2-84.6)	79.9 (76.7-83.0)	77.5 (74.6-80.5)	73.2 (69.6-76.8)	65.2 (64.3-66.0)	63.4 (62.0-64.9)	70.2 (68.5-72.0)	61.8 (59.6-64.0)	82.7 (78.4-87.0)
Height, mean, cm	169 (168-169)	170 (169-170)	169 (168-170)	164 (164-165)	164 (163-165)	165 (163-167)	165 (164-167)	163 (162-165)	166 (165-168)	163 (162-164)	164 (163-165)	165 (163-166)	160 (159-162)	168 (167-170)
BMI, mean[g]	29.2 (28.9-29.5)	29.2 (28.8-29.6)	30.6 (30.2-31.1)	29.9 (29.5-30.4)	30.5 (30.0-31.1)	29.7 (28.6-30.8)	29.1 (27.8-30.4)	29.0 (28.0-30.0)	26.4 (25.2-27.5)	24.4 (24.0-24.7)	23.4 (22.9-23.9)	25.9 (25.2-26.6)	23.9 (23.1-24.6)	29.1 (27.7-30.5)
BMI group[g]														
<23	17.3 (15.7-19.0)	17.0 (15.1-19.0)	15.0 (12.8-17.2)	11.4 (9.2-13.6)	9.0 (6.7-11.3)	14.0 (5.6-22.3)	12.0 (5.6-18.4)	11.5 (5.1-18.0)	24.7 (14.7-34.7)	41.0 (36.0-46.0)	53.1 (46.5-59.8)	25.1 (17.8-32.4)	40.3 (28.1-52.4)	18.8 (11.1-26.5)
23-24.9	12.0 (10.8-13.1)	12.1 (10.5-13.7)	9.0 (7.3-10.8)	9.2 (7.7-10.7)	7.7 (5.5-9.9)	9.6 (2.8-16.3)	7.6 (3.0-12.2)	11.4 (6.1-16.6)	18.0 (11.9-24.2)	20.1 (16.9-23.4)	16.3 (12.5-20.1)	19.8 (14.0-25.7)	28.6 (18.6-38.7)	19.5 (12.2-26.8)
25-29.9	32.6 (31.2-33.9)	33.0 (31.3-34.6)	29.9 (26.5-33.2)	35.6 (32.6-38.6)	35.3 (31.9-38.7)	30.9 (23.0-38.9)	42.3 (26.9-57.8)	41.4 (33.2-49.6)	37.6 (25.1-50.1)	28.7 (25.4-31.9)	23.8 (18.7-28.9)	37.8 (29.7-45.9)	24.2 (15.4-32.9)	25.4 (17.5-33.4)
30-34.9	21.4 (20.0-22.8)	21.4 (19.6-23.3)	22.4 (19.8-25.1)	26.1 (23.3-28.9)	28.0 (24.5-31.6)	30.1 (21.2-39.1)	24.3 (11.3-37.3)	22.3 (14.3-30.3)	13.7 (6.3-21.2)	8.2 (6.6-9.8)	5.9 (3.7-8.1)	13.2 (8.2-18.2)	6.0 (1.9-10.1)	17.9 (12.8-23.0)
≥35	16.7 (15.4-18.1)	16.5 (14.8-18.1)	23.6 (21.6-25.7)	17.7 (15.4-20.0)	20.0 (17.3-22.7)	15.4 (10.6-20.1)	13.8 (8.8-18.7)	13.4 (7.7-19.0)	5.9 (2.2-9.7)	2.0 (1.2-2.7)	0.9 (0.0-1.7)	4.1 (1.1-7.1)	0.9 (0.0-2.3)	18.3 (11.7-24.9)

Abbreviations: BMI, body mass index; NHANES, US National Health and Nutrition Examination Survey.

[a] Unweighted number of all participants in this race/ethnicity category, including other participants in this category who do not belong to a selected subgroup listed in the table.

[b] Includes Costa Rican, Guatemalan, Honduran, Nicaraguan, Panamanian, Salvadoran, Belizean.

[c] Includes Argentinean, Bolivian, Chilean, Colombian, Ecuadorian, Paraguayan, Peruvian, Uruguayan, Venezuelan, other South American.

[d] Includes Chinese, Japanese, and Korean.

[e] Includes Asian Indian, Pakistani, Sri Lankan, and Bangladeshi, Nepali, Bhutanese.

[f] Includes Filipino, Vietnamese, Cambodian, Laotian, Thai, Indonesian, Malaysian, Singaporean, Hmong.

[g] Calculated as weight in kilograms divided by height in meters squared.

Table 2. Weighted Crude and Adjusted Prevalence of Total, Diagnosed, and Undiagnosed Diabetes and Prediabetes by Race/Ethnicity Among US Adults 20 Years or Older, NHANES 2011-2016

Race/Ethnicity[a]	No. of Cases[b]	Crude Prevalence, % (95% CI)	Overall *P* Value[c]	Age-Sex-Adjusted Prevalence, % (95% CI)	Overall *P* Value[c]	Age-Sex-BMI-Adjusted Prevalence, % (95% CI)	Overall *P* Value[c]
Total Diabetes[d]							
All adults[e]	2643	14.6 (13.6-15.7)	<.001		<.001		<.001
Non-Hispanic white	828	13.3 (12.1-14.6)		12.1 (11.0-13.4)		11.9 (10.7-13.0)	
Non-Hispanic black	706	18.3 (16.6-19.9)		20.4 (18.8-22.1)		18.4 (16.8-20.0)	
Hispanic[e]	759	16.6 (14.2-18.9)	<.001	22.1 (19.6-24.7)	<.001	20.3 (18.3-22.4)	.04
Mexican	455	17.8 (14.8-20.8)		24.6 (21.6-27.6)		21.6 (19.0-24.2)	
Puerto Rican	84	19.8 (12.4-27.2)		21.7 (14.6-28.8)		19.9 (13.6-26.2)	
Cuban/Dominican	60	19.3 (10.8-27.7)		20.5 (13.7-27.3)		20.1 (14.5-25.7)	
Central American	56	12.3 (6.8-17.9)		19.3 (12.4-26.1)		19.4 (13.4-25.3)	
South American	39	9.5 (6.2-12.7)		12.3 (8.5-16.2)		14.9 (10.7-19.1)	
Non-Hispanic Asian[e]	281	16.4 (13.4-19.5)	.09	19.1 (16.0-22.1)	.02	27.0 (23.4-30.6)	.05
East Asian	77	12.4 (7.8-17.0)		14.0 (9.5-18.4)		21.3 (15.7-26.9)	
South Asian	77	19.4 (13.3-25.5)		23.3 (15.6-30.9)		27.7 (19.2-36.2)	
Southeast Asian	56	18.9 (12.6-25.2)		22.4 (15.9-28.9)		33.4 (25.7-41.1)	
Non-Hispanic other	69	17.1 (10.5-23.7)		18.5 (11.6-25.3)		17.7 (11.2-24.2)	
Diagnosed Diabetes[f]							
All adults[e]	2266	10.0 (9.3-10.8)	<.001		<.001		<.001
Non-Hispanic white	690	9.1 (8.2-9.9)		8.2 (7.5-9.0)		8.0 (7.2-8.8)	
Non-Hispanic black	637	13.6 (12.4-14.8)		15.4 (14.0-16.7)		13.5 (12.2-14.9)	
Hispanic[e]	649	10.9 (9.4-12.4)	.002	14.9 (13.1-16.6)	<.001	13.4 (12.0-14.9)	.003
Mexican	395	11.8 (9.6-13.9)		16.7 (14.6-18.7)		14.4 (12.5-16.2)	
Puerto Rican	79	16.4 (9.8-23.0)		18.5 (11.5-25.4)		16.7 (11.3-22.1)	
Cuban/Dominican	42	8.5 (5.3-11.8)		9.2 (6.2-12.1)		8.6 (6.5-10.8)	
Central American	42	6.4 (3.6-9.3)		10.5 (6.4-14.7)		10.6 (6.4-14.8)	
South American	33	6.9 (4.1-9.7)		8.9 (5.2-12.6)		10.9 (6.9-14.9)	
Non-Hispanic Asian[e]	228	9.9 (7.9-11.9)	.009	11.6 (9.7-13.6)	.002	17.1 (14.4-19.8)	.002
East Asian	58	6.6 (4.4-8.8)		7.6 (5.3-9.9)		11.5 (8.2-14.8)	
South Asian	65	13.2 (9.4-17.0)		16.0 (11.3-20.7)		19.1 (13.6-24.7)	
Southeast Asian	45	10.7 (6.8-14.6)		12.8 (9.2-16.4)		21.1 (15.6-26.5)	
Non-Hispanic other	62	13.9 (8.7-19.2)		15.1 (9.8-20.4)		14.2 (9.3-19.2)	
Undiagnosed Diabetes[g]							
All adults[e]	377	4.6 (3.9-5.3)	.23		.003		.002
Non-Hispanic white	138	4.3 (3.4-5.2)		3.9 (3.0-4.8)		3.9 (3.0-4.8)	
Non-Hispanic black	69	4.6 (3.4-5.8)		5.2 (3.9-6.4)		4.9 (3.8-6.0)	
Hispanic[e]	110	5.7 (4.4-7.0)	.004	7.5 (5.9-9.1)	<.001	7.1 (5.7-8.5)	.02
Mexican	60	6.0 (4.6-7.5)		8.4 (6.5-10.2)		7.6 (6.0-9.2)	
Puerto Rican	5	3.5 (0.0-7.0)[h]		3.2 (0.4-6.1)[h]		3.2 (0.4-6.0)[h]	
Cuban/Dominican	18	10.7 (4.4-17.0)		11.4 (5.9-17.0)		11.6 (6.4-16.7)	
Central American	14	5.9 (1.4-10.4)[h]		8.8 (2.5-15.1)[h]		8.9 (3.0-14.7)[h]	
South American	6	2.6 (0.7-4.4)[h]		3.3 (1.1-5.4)[h]		4.0 (1.3-6.6)[h]	
Non-Hispanic Asian[e]	53	6.5 (4.1-8.8)	.91	7.5 (4.9-10.0)	.86	10.9 (6.9-15.0)	.69
East Asian	19	5.8 (2.7-8.9)		6.3 (3.3-9.2)		9.9 (5.3-14.5)	
South Asian	12	6.2 (2.1-10.3)[h]		7.5 (2.5-12.5)[h]		9.6 (3.3-15.9)[h]	
Southeast Asian	11	8.2 (2.3-14.1)[h]		9.7 (2.8-16.6)[h]		15.0 (4.7-25.3)[h]	
Non-Hispanic other	7	3.2 (0.7-5.6)[h]		3.4 (0.8-6.0)[h]		3.3 (0.8-5.7)[h]	

(continued)

Table 2. Weighted Crude and Adjusted Prevalence of Total, Diagnosed, and Undiagnosed Diabetes and Prediabetes by Race/Ethnicity Among US Adults 20 Years or Older, NHANES 2011-2016 (continued)

Race/Ethnicity[a]	No. of Cases[b]	Crude Prevalence, % (95% CI)	Overall *P* Value[c]	Age-Sex-Adjusted Prevalence, % (95% CI)	Overall *P* Value[c]	Age-Sex-BMI-Adjusted Prevalence, % (95% CI)	Overall *P* Value[c]
Prediabetes[i]							
All adults[e]	2384	37.5 (35.6-39.4)	.59		.03		.04
Non-Hispanic white	935	37.3 (34.7-39.8)		36.1 (33.6-38.6)		36.2 (33.6-38.8)	
Non-Hispanic black	487	38.3 (35.2-41.4)		39.9 (37.0-42.9)		39.5 (36.4-42.5)	
Hispanic[e]	624	38.3 (35.7-40.9)	.89	41.6 (38.7-44.5)	.76	41.2 (38.4-43.9)	.86
Mexican	355	39.9 (36.2-43.5)		43.5 (39.5-47.4)		42.8 (38.8-46.7)	
Puerto Rican	50	35.9 (26.3-45.5)		37.8 (27.9-47.7)		38.3 (28.3-48.2)	
Cuban/Dominican	55	37.3 (29.1-45.4)		37.7 (30.1-45.3)		38.0 (30.2-45.7)	
Central American	61	36.7 (30.1-43.3)		40.9 (33.8-47.9)		40.8 (33.7-47.8)	
South American	55	35.2 (25.3-45.1)		37.4 (27.2-47.5)		39.3 (29.3-49.4)	
Non-Hispanic Asian[e]	271	35.5 (32.6-38.3)	.79	37.0 (33.9-40.1)	.56	41.4 (38.5-44.4)	.24
East Asian	109	37.4 (31.4-43.4)		39.1 (33.0-45.3)		44.4 (38.7-50.1)	
South Asian	53	32.5 (24.4-40.6)		33.5 (25.5-41.4)		36.4 (28.1-44.8)	
Southeast Asian	43	32.8 (25.1-40.5)		34.6 (27.6-41.7)		39.7 (32.4-47.1)	
Non-Hispanic other	67	38.3 (29.9-46.8)		39.7 (31.5-48.0)		40.1 (31.9-48.4)	

Abbreviations: BMI, body mass index; FPG, fasting plasma glucose; HbA_{1c}, glycated hemoglobin; 2hPG, 2-hour plasma glucose; NHANES, National Health and Nutrition Examination Survey.

[a] For classification scheme of race/ethnicity, see Table 1 (footnotes b-f).

[b] Unweighted total number of participants with diabetes or prediabetes.

[c] Overall *P* value across race/ethnicity groups or subgroups was calculated using the *F* test; the overall *P* value in the line for all adults is for the variation across all major race/ethnicity groups; the overall *P* value in the line of Hispanic is for the variation across all Hispanic subgroups; the overall *P* value in the line of non-Hispanic Asian is for the variation across all non-Hispanic Asian subgroups.

[d] Includes adults with total (ie, self-reported diabetes or undiagnosed) diabetes.

[e] All participants in this race/ethnicity category, including other participants in this category but not belonging to a selected subgroup listed in the table.

[f] Based on self-report of diagnosed diabetes.

[g] Defined as an adult without self-reported diagnosed diabetes but having HbA_{1c} level 6.5% or greater, FPG 126 mg/dL or greater, or 2hPG 200 mg/dL or greater.

[h] Has a relative standard error (standard error/estimate) greater than 30%; estimate is considered unreliable and should be interpreted with caution.

[i] Defined as an adult without total diabetes but with HbA_{1c} level 5.7% or greater to less than 6.5%, an FPG level 100 mg/dL or greater to less than 126 mg/dL, or a 2hPG 140 mg/dL or greater to less than 200 mg/dL.

(95% CI, 25.2-26.6) for South Asian, and 23.9 (95% CI, 23.1-24.6) for Southeast Asian subgroups (*P* < .001 overall).

Education levels also differed significantly among race/ethnicity groups (overall *P* < .001). The proportions with education more than high school were 68.2% (95% CI, 63.2%-73.1%) for non-Hispanic white, 56.0% (95% CI, 52.0%-59.9%) for non-Hispanic black, 40.3% (95% CI, 36.1%-44.5%) for Hispanic, and 73.9% (95% CI, 69.4%-78.5%) for non-Hispanic Asian groups. The proportions with education more than high school also varied among subgroups: among Hispanic subgroups, 33.4% (95% CI, 28.4%-38.4%) for Mexican, 53.2% (95% CI, 37.4%-69.0%) for Puerto Rican, 57.2% (95% CI, 49.3%-65.1%) for Cuban/Dominican, 26.9% (95% CI, 19.0%-34.7%) for Central American, and 69.1% (95% CI, 60.6%-77.5%) for South American subgroups (overall *P* < .001); among non-Hispanic Asian subgroups, 77.7% (95% CI, 70.8%-84.6%) for East Asian, 76.1% (95% CI, 67.7%-84.5%) for South Asian, and 60.0% (95% CI, 48.4%-71.6%) for Southeast Asian subgroups (overall *P* = .03).

The crude prevalence of total diabetes was 14.6% (95% CI, 13.6%-15.7%), including 10.0% (95% CI, 9.3%-10.8%) with diagnosed diabetes and 4.6% (95% CI, 3.9%-5.3%) with undiagnosed diabetes; 37.5% (95% CI, 35.6%-39.4%) had prediabetes (**Table 2**).

The age- and sex-adjusted prevalence of total diabetes and diagnosed diabetes were different among major race/ethnicity groups (overall *P* < .001), among Hispanic subgroups (overall *P* < .001), and among non-Hispanic Asian subgroups (overall *P* = .02). After adjusting for age and sex, the prevalence of total diabetes was 12.1% (95% CI, 11.0%-13.4%) for non-Hispanic white, 20.4% (95% CI, 18.8%-22.1%) for non-Hispanic black, 22.1% (95% CI, 19.6%-24.7%) for Hispanic, and 19.1% (95% CI, 16.0%-22.1%) for non-Hispanic Asian groups (overall *P* < .001). Among Hispanic subgroups, the prevalence of total diabetes was 24.6% (95% CI, 21.6%-27.6%) for Mexican, 21.7% (95% CI, 14.6%-28.8%) for Puerto Rican, 20.5% (95% CI, 13.7%-27.3%) for Cuban/Dominican, 19.3% (95% CI, 12.4%-26.1%) for Central American, and 12.3% (95% CI, 8.5%-16.2%) for South American subgroups (overall *P* < .001). Among non-Hispanic Asian subgroups, the adjusted prevalence of total diabetes was 14.0% (95% CI, 9.5%-18.4%) for East Asian, 23.3% (95% CI, 15.6%-30.9%) for South Asian, and 22.4% (95% CI, 15.9%-28.9%) for Southeast Asian subgroups (overall *P* = .02).

After additional adjustment for BMI, 20.3% (95% CI, 18.3%-22.4%) of Hispanic participants and 27.0% (95% CI, 23.4%-30.6%) of non-Hispanic Asian participants had diagnosed or undiagnosed diabetes. After adjusting for age and sex, prevalences of undiagnosed diabetes were 3.9% (95% CI,

Table 3. Weighted Age- and Sex-Adjusted Proportion of Undiagnosed Diabetes by Diagnostic Test Type Among Adults With Diabetes or Without Diagnosed Diabetes Aged 20 Years or Older, NHANES 2011-2016

	Among Adults With Diagnosed or Undiagnosed Diabetes[b,c]		Among Adults Without Diagnosed Diabetes[b]							
				% (95% CI)						
Race/Ethnicity[a]	No. of Participants[d]	Undiagnosed Diabetes, % (95% CI)	No. of Participants[d]	Undiagnosed Diabetes (A)	HbA_{1c} ≥6.5% (B)	FPG ≥126 mg/dL (C)	2hPG ≥200 mg/dL (D)	B/A	C/A	D/A
All adults[e]	2643	31.4 (27.8-34.9)	5309	5.1 (4.3-5.9)	2.0 (1.6-2.4)	2.3 (1.9-2.7)	4.1 (3.4-4.8)	39.2 (30.8-50.1)	45.1 (44.1-61.0)	80.4 (74.1-87.5)
Non-Hispanic white	828	32.4 (27.0-37.7)	2176	4.2 (3.2-5.2)	1.3 (0.8-1.8)	1.9 (1.4-2.4)	3.5 (2.6-4.4)	31.0 (21.1-45.3)	45.2 (30.7-66.7)	83.3 (60.3-99.9)
Non-Hispanic black	706	24.8 (19.7-29.9)	999	6.4 (4.9-7.8)	3.8 (2.7-4.9)	2.1 (1.0-3.1)	4.4 (2.9-5.8)	59.4 (42.5-83.0)	32.8 (19.6-54.8)	68.8 (47.1-99.9)
Hispanic[e]	759	33.2 (28.1-38.3)	1303	8.9 (7.0-10.9)	4.1 (2.7-5.5)	4.0 (2.4- 5.5)	6.7 (5.0-8.4)	46.1 (30.9-68.8)	44.9 (28.7-70.5)	75.3 (54.6-99.9)
Mexican	455	32.8 (27.8-37.8)	712	10.2 (7.6-12.7)	5.1 (3.1-7.1)	5.0 (2.8-7.2)	8.0 (5.6-10.3)	50.0 (31.6-79.1)	49.0 (29.8-80.7)	78.4 (53.3-99.9)
Puerto Rican	84	12.7 (2.0-23.5)[f]	99	3.9 (0.0-8.7)[f]	1.0 (0.0-2.4)[f]	NA	2.9 (0.0-6.6)[f]	25.6 (4.1-99.9)[f]	NA	71.8 (11.9-99.9)[f]
Cuban/Dominican	60	56.3 (44.0-68.6)	118	12.8 (6.2-19.3)[f]	5.7 (1.3-10.0)[f]	3.6 (0.0-7.2)[f]	9.2 (3.8-14.6)	44.5 (17.9-99.9)[f]	42.2 (14.5-99.9)[f]	71.9 (33.4-99.9)[f]
Central American	56	47.8 (25.8-69.7)[f]	145	10.1 (3.0-17.2)[f]	3.3 (0.2-6.3)[f]	3.6 (0.0-7.5)[f]	6.3 (0.8-11.7)[f]	32.7 (10.7-99.9)[f]	35.6 (9.9-99.9)[f]	62.4 (21.2-99.9)[f]
South American	39	25.9 (8.3-43.5)[f]	131	3.6 (1.3-5.8)	0.8 (0.0-2.2)[f]	1.0 (0.0-2.5)[f]	3.3 (1.0-5.5)[f]	22.2 (3.6-99.9)[f]	30.6 (7.7-99.9)[f]	91.7 (37.8-99.9)[f]
Non-Hispanic Asian[e]	281	37.9 (28.6-47.3)	681	8.6 (5.5-11.7)	3.7 (2.1-5.4)	4.3 (2.6-6.1)	7.4 (4.4-10.3)	43.0 (25.0-74.2)	50.0 (29.3-85.3)	86.0 (50.9-99.9)
East Asian	77	41.2 (29.3-53.0)	144	7.0 (3.2-10.8)	1.9 (0.2-3.6)[f]	3.6 (1.4-5.8)[f]	6.3 (2.7-9.8)	27.1 (10.2-99.9)[f]	51.4 (23.1-99.9)[f]	90.0 (41.6-99.9)[f]
South Asian	77	29.8 (13.8-45.6)[f]	118	9.3 (2.3-16.4)[f]	4.9 (0.0-9.8)[f]	4.9 (0.1-9.8)[f]	6.0 (0.0-12.1)[f]	52.7 (15.2-99.9)[f]	52.7 (15.7-99.9)[f]	64.5 (18.9-99.9)[f]
Southeast Asian	56	44.1 (22.0-66.2)[f]	155	11.2 (3.3-19.2)[f]	5.8 (1.2-10.5)[f]	3.3 (0.5-6.2)[f]	10.1 (2.0-18.3)[f]	51.8 (18.2-99.9)[f]	29.5 (8.2-99.9)[f]	90.2 (31.3-99.9)[f]
Non-Hispanic other	69	17.5 (6.5-28.6)[f]	150	3.7 (0.4-7.0)[f]	1.6 (0.0-3.7)[f]	3.0 (0.1-6.0)[f]	2.8 (0.1-5.4)[f]	43.2 (8.6-99.9)[f]	81.1 (21.4-99.9)[f]	75.7 (21.0-99.9)[f]

Abbreviations: FPG, fasting plasma glucose; HbA_{1c}, glycated hemoglobin; 2hPG, 2-hour plasma glucose; NA, not available (no case); NHANES, National Health and Nutrition Examination Survey.

SI conversion factor: To convert glucose values to mmol/L, multiply by 0.0555.

[a] For classification scheme of race/ethnicity, see Table 1 (footnotes b-f).

[b] Based on self-report of diagnosed diabetes.

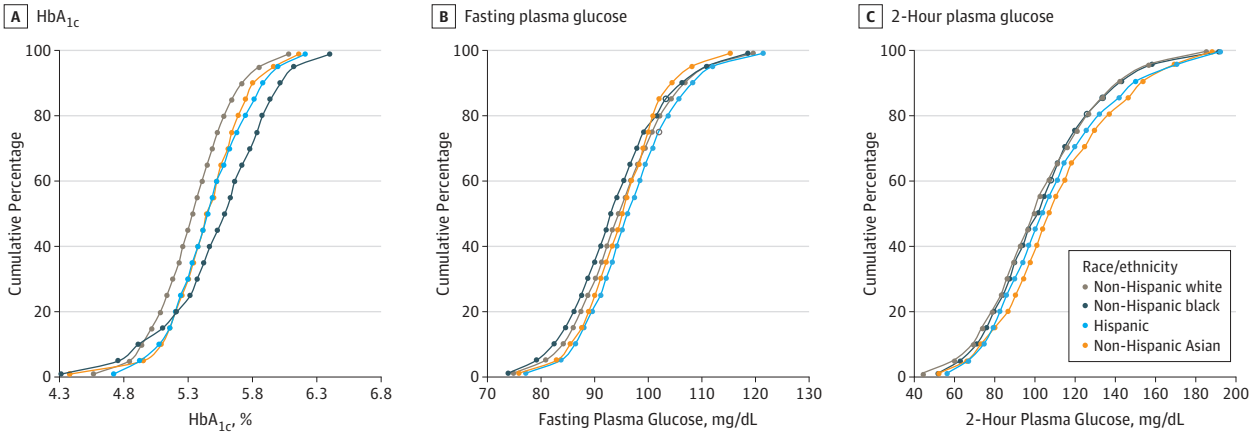
[c] Defined as an adult without self-reported diagnosed diabetes but with HbA_{1c} level 6.5% or greater, FPG 126 mg/dL or greater, or 2hPG 200 mg/dL or greater.

[d] Unweighted total number of participants in a category.

[e] All participants in this race/ethnicity category, including other participants in this category but not belonging to a selected subgroup listed in the table.

[f] Has a relative standard error (standard error/estimate) greater than 30%; estimate is considered unreliable and should be interpreted with caution.

Figure. Age- and Sex-Adjusted Distribution of HbA_{1c}, Fasting Plasma Glucose, and 2-Hour Plasma Glucose Values Among Adults 20 Years or Older Without Diabetes by Major Race/Ethnicity Group, NHANES 2011-2016



To estimate the percentiles of the distribution of HbA_{1c}, fasting plasma glucose, and 2-hour plasma glucose among adults without diabetes (previously diagnosed or undiagnosed), 4789 participants without diabetes were included in this Figure (2038 non-Hispanic white, 930 non-Hispanic black, 1193 Hispanic, and 628 non-Hispanic Asian; 143 non-Hispanic participants without diabetes who did not fall into these categories were not included because of unreliable estimates). To convert glucose values to mmol/L, multiply by 0.0555. HbA_{1c} indicates glycated hemoglobin; NHANES, National Health and Nutrition Examination Survey.

3.0%-4.8%) for non-Hispanic white, 5.2% (95% CI, 3.9%-6.4%) for non-Hispanic black, 7.5% (95% CI, 5.9%-9.1%) for Hispanic, and 7.5% (95% CI, 4.9%-10.0%) for non-Hispanic Asian groups (overall $P = .003$). The age- and sex-adjusted prevalence of prediabetes was 36.1% (95% CI, 33.6%-38.6%) for non-Hispanic white, 39.9% (95% CI, 37.0%-42.9%) for non-Hispanic black, 41.6% (95% CI, 38.7%-44.5%) for Hispanic, and 37.0% (95% CI, 33.9%-40.1%) for non-Hispanic Asian groups (overall $P = .03$). There were no significant differences in prediabetes prevalence among the Hispanic or non-Hispanic Asian subgroups.

The difference in prevalence of undiagnosed diabetes was significant among race/ethnicity groups (overall $P = .003$) (Table 2), and the proportion of undiagnosed diabetes among adults with total diabetes was also significant: 32.4% (95% CI, 27.0%-37.7%) for non-Hispanic white, 24.8% (95% CI, 19.7%-29.9%) for non-Hispanic black, 33.2% (95% CI, 28.1%-38.3%) for Hispanic, and 37.9% (95% CI, 28.6%-47.3%) for non-Hispanic Asian groups (overall $P = .04$) (**Table 3**).

Among US adults without diagnosed diabetes, none of the 3 diagnostic tests detected all undiagnosed diabetes based on current diagnostic cutpoints (Table 3). Among adults without diagnosed diabetes, the proportion that met criteria for undiagnosed diabetes as defined by each diagnostic test were 2.0% (95% CI, 1.6%-2.4%) using HbA_{1c} values, 2.3% (95% CI, 1.9%-2.7%) using FPG values, and 4.1% (95% CI, 3.4%-4.8%) using 2hPG values. Among adults without diagnosed diabetes, 2hPG alone identified 80.4% (95% CI, 74.1%-87.5%) of undiagnosed diabetes, which was higher than HbA_{1c} alone (39.2% [95% CI, 30.8%-50.1%]) ($P < .001$) or FPG alone (45.1% [95% CI, 44.1%- 61.0%]) ($P < .001$).

To estimate the age- and sex-adjusted percentiles of the distribution of HbA_{1c}, FPG, and 2hPG values among adults without total diabetes, 4789 participants without total diabetes were included: 2038 non-Hispanic white, 930 non-Hispanic black, 1193 Hispanic, and 628 non-Hispanic Asian; 143 non-Hispanic participants without diabetes who did not fall into these categories were not included because of unreliable estimates. The **Figure** shows the age- and sex-adjusted cumulative probabilities of distribution for HbA_{1c}, FPG, and 2hPG values among participants without total diabetes. The differences in medians by major race/ethnicity group were statistically significant (all overall P values <.001). Non-Hispanic black participants had a median HbA_{1c} of 5.6% (95% CI, 5.5%-5.6%), followed by Hispanic (5.5% [95% CI, 5.4%-5.5%]), non-Hispanic Asian (5.4% [95% CI, 5.4%-5.5%]), and non-Hispanic white (5.3% [95% CI, 5.3%-5.4%]) participants. Hispanic participants had a median FPG of 96.1 mg/dL (95% CI, 95.2-97.3), followed by non-Hispanic Asian (95.2 mg/dL [95% CI, 94.0-95.9]), non-Hispanic white (94.5 mg/dL [95% CI, 93.7-95.5]), and non-Hispanic black (93.0 mg/dL [95% CI, 92.2-93.9]) participants. Non-Hispanic Asian participants had the median 2hPG (107.2 mg/dL [95% CI, 104.2-110.0]), followed by Hispanic (103.8 mg/dL [95% CI, 100.4-106.5]), non-Hispanic black (101.7 mg/dL [95% CI, 100.2-104.1]), and non-Hispanic white (99.5 mg/dL [95% CI, 98.2-101.6]) participants. After additional adjustment for BMI, the distributions of HbA_{1c}, FPG, and 2hPG values for non-Hispanic Asian participants shifted higher (eFigure in the Supplement).

Discussion

In this nationally representative study of the US population from 2011 to 2016, the age- and sex-adjusted prevalences of undiagnosed diabetes and total diabetes were high among Hispanic, non-Hispanic black, and non-Hispanic Asian groups compared with the non-Hispanic white group. There was considerable heterogeneity in diabetes prevalence among Hispanic subgroups and among non-Hispanic Asian subgroups. Among

adults with undiagnosed diabetes, a high proportion were identified using the 2hPG test.

Other studies have shown that, compared with individuals in other race/ethnicity groups, Asian individuals with diabetes have lower BMI values.[18] Although the associations between BMI and diabetes were comparably strong across race/ethnicity groups, the BMI cutpoint for increased risk for type 2 diabetes is much lower among Asian individuals than those in other major race/ethnicity groups.[19,20] In this study, after adjusting for age, sex, and BMI, Southeast Asian participants had the highest total diabetes prevalence among non-Hispanic Asian subgroups. The effect of BMI adjustment on glucose distributions was also observed among non-Hispanic Asian participants without diabetes.

The 2hPG test detected the greatest proportion of undiagnosed diabetes in this study. A previous study showed that the proportion of diabetes detected by 2hPG testing was high among Asian adults.[21] In this study, the proportion of undiagnosed diabetes detected by each of the 3 glucose tests varied among the race/ethnicity groups. Diabetes may be underdiagnosed without the 2hPG test,[22] especially among Hispanic and non-Hispanic Asian groups. The HbA_{1c} test, recommended by the American Diabetes Association, is more clinically convenient than the other 2 tests. In general, the higher proportion of undiagnosed diabetes identified using the 2hPG test could also reflect the reluctance of health care professionals to use the 2hPG test for detection of diabetes.

Racial/ethnical differences in diabetes detection by test type may be due to underlying physiological causes. FPG reflects hepatic glucose production, 2hPG reflects inadequate suppression of hepatic glucose production and reduced glucose uptake by splanchnic and peripheral tissues, and HbA_{1c} reflects the average glucose level in the previous 2 to 3 months.[23] Other studies have reported that non-Hispanic black persons had higher levels of HbA_{1c} than non-Hispanic white persons,[24] possibly because of a higher prevalence of hemoglobinopathies or other pathophysiologic or genetic factors.[25] Similarly, isolated elevated HbA_{1c} levels have been reported in South Asian persons.[26] This study showed that for non-Hispanic black participants, the whole distribution of HbA_{1c} levels shifted higher than for any other race/ethnicity group. Thus, race/ethnicity differences in the prevalence of undiagnosed diabetes may be related to physiological differences.

Limitations

This study had several limitations. First, because the survey was cross-sectional, cause-effect inferences cannot be made. Second, despite oversampling of Hispanic and non-Hispanic Asian groups, NHANES 2011-2016 was still limited by small sample sizes for single Hispanic or non-Hispanic Asian subgroups for some estimates. Nevertheless, the current study provides a benchmark for comparison of future national estimates for Hispanic and non-Hispanic Asian groups. Third, diabetes type was not available, diagnosed diabetes was self-reported, and undiagnosed diabetes was defined by a 1-time measurement of glucose level in a single blood sample, so there is a possibility of misclassification in both directions.[27,28] Fourth, NHANES only includes noninstitutionalized civilians; thus, the analysis may underrepresent some segments of the US population. Fifth, race/ethnicity groups were self-reported and US immigrants are vastly diverse; the race/ethnicity subgroups may not be finely enough defined to account for people emigrating from regions with varying lifestyle and dietary patterns, or over varying time periods.

Conclusions

In this nationally representative survey of US adults from 2011 to 2016, the prevalence of diabetes and undiagnosed diabetes varied by race/ethnicity and among subgroups identified within the Hispanic and non-Hispanic Asian populations.

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Concept and design: Cheng, Kanaya, Gregg, Imperatore.
Acquisition, analysis, or interpretation of data: Cheng, Araneta, Saydah, Kahn, Fujimoto, Imperatore.
Drafting of the manuscript: Cheng, Imperatore.
Critical revision of the manuscript for important intellectual content: All authors.
Statistical analysis: Cheng.
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REFERENCES

1. Colby SL, Ortman JM. Projections of the size and composition of the US population: 2014 to 2060: population estimates and projections. US Census Bureau website. https://census.gov/library/publications/2015/demo/p25-1143.html. Published 2015. Accessed October 23, 2019.

2. Cho NH, Shaw JE, Karuranga S, et al. IDF Diabetes Atlas: global estimates of diabetes prevalence for 2017 and projections for 2045. *Diabetes Res Clin Pract*. 2018;138:271-281. doi:10.1016/j.diabres.2018.02.023

3. Arroyo-Johnson C, Mincey KD, Ackermann N, Milam L, Goodman MS, Colditz GA. Racial and ethnic heterogeneity in self-reported diabetes prevalence trends across Hispanic subgroups, National Health Interview Survey, 1997-2012. *Prev Chronic Dis*. 2016;13:E10. doi:10.5888/pcd13.150260

4. Rhee EJ. Diabetes in Asians. *Endocrinol Metab (Seoul)*. 2015;30(3):263-269. doi:10.3803/EnM.2015.30.3.263

5. Kanaya AM, Herrington D, Vittinghoff E, et al. Understanding the high prevalence of diabetes in U.S. south Asians compared with four racial/ethnic groups: the MASALA and MESA studies. *Diabetes Care*. 2014;37(6):1621-1628. doi:10.2337/dc13-2656

6. Schneiderman N, Llabre M, Cowie CC, et al. Prevalence of diabetes among Hispanics/Latinos from diverse backgrounds: the Hispanic Community Health Study/Study of Latinos (HCHS/SOL). *Diabetes Care*. 2014;37(8):2233-2239. doi:10.2337/dc13-2939

7. Menke A, Casagrande S, Geiss L, Cowie CC. Prevalence of and trends in diabetes among adults in the United States, 1988-2012. *JAMA*. 2015;314(10):1021-1029. doi:10.1001/jama.2015.10029

8. Centers for Disease Control and Prevention (CDC). NHANES questionnaires, datasets, and related documentation. CDC website. https://wwwn.cdc.gov/nchs/nhanes/default.aspx. Published 2018. Accessed October 23, 2019.

9. Centers for Disease Control and Prevention (CDC). NHANES response rates and CPS totals. CDC website. https://wwwn.cdc.gov/nchs/nhanes/ResponseRates.aspx. Published 2018. Accessed October 23, 2019.

10. Johnson CL, Dohrmann SM, Burt VL, Mohadjer LK. National health and nutrition examination survey: sample design, 2011-2014. *Vital Health Stat 2*. 2014;(162):1-33.

11. Paulose-Ram R, Burt V, Broitman L, Ahluwalia N. Overview of Asian American data collection, release, and analysis: National Health and Nutrition Examination Survey 2011-2018. *Am J Public Health*. 2017;107(6):916-921. doi:10.2105/AJPH.2017.303815

12. Seaman SR, White IR. Review of inverse probability weighting for dealing with missing data. *Stat Methods Med Res*. 2013;22(3):278-295. doi:10.1177/0962280210395740

13. Centers for Disease Control and Prevention (CDC). US diabetes resources and publications. CDC website. https://www.cdc.gov/diabetes/resources-publications/index.html. Published 2019. Accessed October 23, 2019.

14. Centers for Disease Control and Prevention (CDC). NHANES Survey Methods and Analytic Guidelines, 2011-2014 and 2015-2016. CDC website. https://wwwn.cdc.gov/nchs/data/nhanes/2011-2012/analyticguidelines/analytic_guidelines_11_16.pdf. Published 2018. Accessed October 23, 2019.

15. Graubard BI, Korn EL. Predictive margins with survey data. *Biometrics*. 1999;55(2):652-659. doi:10.1111/j.0006-341X.1999.00652.x

16. Parr WC. A note on the jackknife, the bootstrap and the delta method estimators of bias and variance. *Biometrika*. 1983;70(3):719-722. doi:10.1093/biomet/70.3.719

17. Parker JD, Talih M, Malec DJ, et al. National Center for Health Statistics data presentation standards for proportions. *Vital Health Stat 2*. 2017;(175):1-22.

18. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies [published correction appears in *Lancet*. 2004;363(9412):902]. *Lancet*. 2004;363(9403):157-163. doi:10.1016/S0140-6736(03)15268-3

19. Hsu WC, Araneta MR, Kanaya AM, Chiang JL, Fujimoto W. BMI cut points to identify at-risk Asian Americans for type 2 diabetes screening. *Diabetes Care*. 2015;38(1):150-158. doi:10.2337/dc14-2391

20. American Diabetes Association. Classification and diagnosis of diabetes: *Standards of Medical Care in Diabetes*—2019. *Diabetes Care*. 2019;42(suppl 1):S13-S28. doi:10.2337/dc19-S002

21. Araneta MR, Kanaya AM, Hsu WC, et al. Optimum BMI cut points to screen Asian Americans for type 2 diabetes. *Diabetes Care*. 2015;38(5):814-820. doi:10.2337/dc14-2071

22. Meijnikman AS, De Block CEM, Dirinck E, et al. Not performing an OGTT results in significant underdiagnosis of (pre)diabetes in a high risk adult Caucasian population. *Int J Obes (Lond)*. 2017;41(11):1615-1620. doi:10.1038/ijo.2017.165

23. Abdul-Ghani MA, Tripathy D, DeFronzo RA. Contributions of beta-cell dysfunction and insulin resistance to the pathogenesis of impaired glucose tolerance and impaired fasting glucose. *Diabetes Care*. 2006;29(5):1130-1139. doi:10.2337/dc05-2179

24. Ziemer DC, Kolm P, Weintraub WS, et al. Glucose-independent, black-white differences in hemoglobin A_{1c} levels: a cross-sectional analysis of 2 studies. *Ann Intern Med*. 2010;152(12):770-777. doi:10.7326/0003-4819-152-12-201006150-00004

25. Kirk JK, D'Agostino RB Jr, Bell RA, et al. Disparities in HbA_{1c} levels between African-American and non-Hispanic white adults with diabetes: a meta-analysis. *Diabetes Care*. 2006;29(9):2130-2136. doi:10.2337/dc05-1973

26. Gujral UP, Prabhakaran D, Pradeepa R, et al. Isolated HbA_{1c} identifies a different subgroup of individuals with type 2 diabetes compared to fasting or post-challenge glucose in Asian Indians: the CARRS and MASALA studies. *Diabetes Res Clin Pract*. 2019;153:93-102. doi:10.1016/j.diabres.2019.05.026

27. Selvin E, Crainiceanu CM, Brancati FL, Coresh J. Short-term variability in measures of glycemia and implications for the classification of diabetes. *Arch Intern Med*. 2007;167(14):1545-1551. doi:10.1001/archinte.167.14.1545

28. Selvin E, Wang D, Matsushita K, Grams ME, Coresh J. Prognostic implications of single-sample confirmatory testing for undiagnosed diabetes: a prospective cohort study. *Ann Intern Med*. 2018;169(3):156-164. doi:10.7326/M18-0091