# Prevalence of diagnosed type 1 and type 2 diabetes among US adults in 2016 and 2017: population based study

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## ABSTRACT

### OBJECTIVE
To estimate the prevalence of diagnosed total diabetes, type 1 diabetes, and type 2 diabetes in the US general population and the proportions of each among US adults with a diagnosis of diabetes.

### DESIGN
Nationwide, population based, cross sectional survey.

### SETTING
National Health Interview Survey, 2016 and 2017.

### PARTICIPANTS
Adults aged 20 years or older (n=58 186), as a nationally representative sample of the civilian, non-institutionalized US population.

### MAIN OUTCOME MEASURES
Prevalence of diagnosed diabetes, type 1 diabetes, and type 2 diabetes in the US general population, and the proportions of each subtype in participants with a diagnosis of diabetes.

### RESULTS
Among the 58 186 included adults, 6317 had received a diagnosis of diabetes. The weighted prevalence of diagnosed diabetes, type 1 diabetes, and type 2 diabetes among US adults was 9.7% (95% confidence interval 9.4% to 10.0%), 0.5% (0.5% to 0.6%), and 8.5% (8.2% to 8.8%), respectively. Type 1 diabetes was more prevalent among adults with lower education level, and type 2 diabetes was more prevalent among older adults, men, and those with lower educational level, lower family income level, and higher body mass index (BMI). Among adults with a diagnosis of diabetes, the weighted percentage of type 1 and type 2 diabetes was 5.6% (4.9% to 6.4%) and 91.2% (90.4% to 92.1%), respectively. The percentage of type 1 diabetes was higher among younger adults (age 20-44 years), non-Hispanic white people, those with higher education level, and those with lower BMI, whereas the percentage of type 2 diabetes was higher among older adults (age ≥65 years), non-Hispanic Asians, those with lower education level, and those with higher BMI.

### CONCLUSION
This study provided benchmark estimates on the national prevalence of diagnosed type 1 diabetes (0.5%) and type 2 diabetes (8.5%) among US adults. Among US adults with diagnosed diabetes, type 1 and type 2 diabetes accounted for 5.6% and 91.2%, respectively.

## Introduction

Diabetes, encompassing type 1 and type 2 diabetes and other subtypes, is a major public health concern in the United States and elsewhere.[1 2] In 2015, 9.4% of the US population (30.3 million people) was estimated to have diabetes.[3] In the same year, the global number of adults with diabetes was estimated at 415 million, with a projected increase to 642 million by 2040.[2] Diabetes not only results in specific complications[4] but also increases the risk of cardiovascular disease,[5] cancer,[6] and all cause mortality.[7 8] The economic burden of diabetes in adults is substantial—roughly $245bn (£174bn; €199bn) in the United States in 2012[9] and $1.31tn worldwide in 2015.[10]

The causes of type 1 and type 2 diabetes differ, as do the clinical manifestations and treatments.[11] Type 2 diabetes–the predominant subtype of diabetes—mostly develops in adulthood.[11 12] In contrast, type 1 diabetes usually develops in childhood and is considered rare among adults.[11 13 14] Although previous studies in the United States[15-17] and elsewhere[18] have reported the prevalence of diabetes among adults on the basis of national health surveys,[15-17] little is known about the prevalence by diabetes subtypes (eg, type 1 and type 2 diabetes) in adulthood.

Because type 2 diabetes predominates among adults,[11 12 14] previous reported prevalence and trends in diabetes[15-17] were likely representative of this subtype. With the continuing improvement in treatment of type 1 diabetes,[11 13] more children with this form of diabetes are expected to survive to adulthood.

Using data from the National Health Interview Survey (NHIS), one of the leading health surveys in the United States, we estimated the prevalence of diagnosed type 1 and type 2 diabetes in 2016 and 2017 and the proportions of these subtypes among US adults with a diagnosis of diabetes.

## Methods

### Study population

The NHIS is a continuous, nationwide cross sectional household interview survey conducted each year

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**WHAT IS ALREADY KNOWN ON THIS TOPIC**

Although studies have reported the prevalence of diabetes among adults in the United States and worldwide, data on prevalence of diabetes by subtypes are scarce

Type 2 diabetes, the predominant form of diabetes, is assumed to account for 90% or more of all diabetes cases in adults

**WHAT THIS STUDY ADDS**

The prevalence of diagnosed type 1 and type 2 diabetes in 2016 and 2017 among US adults was 0.5% and 8.5%, respectively

Among adults with diabetes, the weighted percentage of type 1 and type 2 diabetes was 5.6% and 91.2%, respectively

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by the National Center for Health Statistics at the Centers for Disease Control and Prevention. The NHIS focuses on the civilian non-institutionalized population residing in the United States at the time of the interview. Exclusion criteria are those in long term care institutions and correctional facilities and US nationals living in foreign countries. Since its inception in 1957, the NHIS has become the principal source of information on the health status of the US population,[19] and the data have been widely used in reports on diabetes prevalence and trends among US adults.[3 15 20] The NHIS uses a multistage probability sampling, which enables nationally representative sampling. The multistage methods partition the target population into several nested levels of stratums and clusters. In 2016 and 2017, the NHIS surveyed a sample of 319 of 1700 geographically defined primary sampling units in each of the 50 states and in the District of Columbia. A primary sampling unit consists of a county, a small group of contiguous counties, or a metropolitan statistical area. The annual sample size for households is about 35 000 containing about 87 500 children and adults. A detailed description of the survey design, methods, and sample weights in the NHIS is published elsewhere.[21] The NHIS was approved by the research ethics review board of the National Center for Health Statistics and US Office of Management and Budget. All respondents provided oral consent before participation.

### Data collection

The NHIS collects data on a broad range of health topics through face-to-face household interviews. The total household response rate was 67.9% in 2016 and 66.5% in 2017, and the conditional response rate for the adult sample was 80.9% in 2016 and 80.7% in 2017.

Respondents were asked whether they had ever been told by a health professional that they had diabetes or sugar diabetes.[15] For women, this question specifically asked about diabetes other than during pregnancy. Approximately 99.9% of the adult participants in both NHIS 2016 and NHIS 2017 responded to this question.

Since 2016, the NHIS asked participants who had ever received a diagnosis of diabetes to report the subtypes (ie, type 1 or type 2, other types, or unknown). Among those with an ever diagnosis of diabetes, 96% reported the subtype and only 4% reported unknown subtypes (n=253) or refused to report subtypes (n=3). In addition, the participants were asked about age at diabetes diagnosis, use of drugs, use of insulin, and timing of the initiation of insulin. Respondents who self reported type 1 diabetes and current insulin use were classified as having type 1 diabetes. Respondents who self reported other diabetes types were classified as having other type diabetes. All the remaining people with diabetes, except those who reported unknown subtypes or refused to report subtypes, were classified as having type 2 diabetes.

A standardized questionnaire was used to collect information on age, sex, race/ethnicity, education, family income, body weight, and height. Age was grouped into three categories: 20-44 years (younger adults), 45-64 years (middle aged adults), and 65 years and older (older adults). The participants self reported their race and Hispanic origin in response to specific questions. In this analysis, we categorized race/ethnicity into Hispanic, non-Hispanic white, non-Hispanic black, non-Hispanic Asian, and other. The family income to poverty ratio is a measure of family income relative to poverty guidelines specific to the survey year. We classified family income levels into four categories: income poverty ratio <1.0, 1.0-1.9, 2.0-3.9, and ≥4.0. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters.

### Statistical analysis

In all analyses we used survey weights to account for unequal probabilities of selection, oversampling, and non-response in the survey. Therefore, all the reported estimates were representative of the civilian, non-institutionalized US population.

Appendix figure 1 shows the flowchart of participant inclusion in the study. We estimated the weighted prevalence of diabetes and of type 1 and type 2 diabetes and the weighted percentages of type 1 and type 2 diabetes among those with an ever diagnosis of diabetes. Using the direct method, we age standardized stratified estimates by sex, race/ethnicity, family income, education, and BMI to allow comparisons independent of age. We age adjusted estimates to the 2010 US census population using standardizing proportions for the age groups 20-44 years, 45-64 years, and 65 years or older. The Rao-Scott $\chi^2$ test with an adjusted F statistic was used to calculate the P value for overall differences in prevalence or percentages across stratums. Logistic regression models were used to assess the associations of age, sex, race/ethnicity, family income, education, and BMI with prevalence of type 1 and type 2 diabetes.

All data analyses were conducted using survey procedures in SAS 9.4 (SAS Institute, Cary, NC). A two sided P value <0.05 was considered statistically significant.

### Patient involvement

No patients were involved in setting the research question or the outcome measures, nor were they involved in developing plans for recruitment, design, or implementation of the study. No patients were asked to advise on interpretation or writing up of results. This study used deidentified information collected in a national health survey. There are no plans to disseminate the results of the research to study participants or the relevant patient community.

### Results

Among the 58 186 included adults aged 20 years or older, 6317 had received a diagnosis of diabetes. The weighted prevalence of diagnosed diabetes was 9.7% (95% confidence interval 9.4% to 10.0%), which

was comparable to that recorded for 2015 in the Centers for Disease Control and Prevention's latest National Diabetes Statistics Report.[3] The prevalence of diagnosed diabetes differed statistically significantly by age, sex, race/ethnicity, education, family income, and BMI (table 1). The prevalence of diagnosed diabetes did not differ by survey year, with the weighted prevalence of 9.7% (9.3% to 10.2%) in 2016 and 9.7% (9.2% to 10.1%) in 2017.

The weighted prevalence of diagnosed type 1 diabetes, type 2 diabetes, and other subtypes was 0.5% (0.5% to 0.6%), 8.5% (8.2% to 8.8%), and 0.3% (0.2% to 0.3%), respectively. Type 1 diabetes was more prevalent among adults with lower education level, and type 2 diabetes was more prevalent among men and those with lower education level, lower family income level, and higher BMI (table 2). Among adults with a diagnosis of diabetes, the weighted percentage of type 1 and type 2 diabetes was 5.6% (4.9% to 6.4%) and 91.2% (90.4% to 92.1%), respectively (table 2). The percentage of type 1 diabetes was higher among younger adults (age 20-44 years), non-Hispanic white people, those with higher education level, and those with lower BMI, whereas the percentage of type 2 diabetes was higher among older adults (age ≥65 years), non-Hispanic Asians, those with lower education level, and those with higher BMI (table 2). In multivariable logistic regression models, we found that age, sex, race/ethnicity, education level, family income level, and BMI were statistically significant risk factors for diagnosed type 2 diabetes in adults, whereas sex, race/ethnicity, and family income level were statistically significantly associated with diagnosed type 1 diabetes (table 3).

## Discussion

On the basis of information from a nationally representative survey in the United States in 2016 and 2017, we estimated that 0.5% of US adults had a diagnosis of type 1 diabetes and 8.5% had a diagnosis of type 2 diabetes. The prevalence of both subtypes varied statistically significantly by age, sex, race/ethnicity, education, family income, and body mass index (BMI). Moreover, the patterns of these variables were distant between participants with diagnosed type 1 diabetes and those with diagnosed type 2 diabetes. Among US adults with a diagnosis of diabetes, type 1 diabetes accounted for 5.6% of cases and type 2 diabetes accounted for 91.2% of cases.

### Results in relation to other studies

Previous national surveys among US adults have focused on the prevalence of diabetes regardless of the subtypes.[15-17] Our estimates on prevalence of diabetes overall were comparable with those of previous studies.[15-17] Little is known about the prevalence of type 1 and type 2 diabetes among US adults, and the paucity of such data not only applies to the US but to

### Table 1 | Prevalence of diagnosed diabetes among US adults in 2016 and 2017 (n=58 186)

| Characteristics | No of participants* | No with diabetes* | Prevalence, % (95% CI)† | P value‡ |
|---|---|---|---|---|
| Overall | 58 186 | 6317 | 9.7 (9.4 to 10.0) | |
| Age adjusted | 58 186 | 6317 | 9.3 (9.0 to 9.7) | |
| Age (years): | | | | |
| 20-44 | 21 794 | 632 | 2.9 (2.6 to 3.2) | |
| 45-64 | 20 182 | 2512 | 12.4 (11.7 to 13.0) | 0.001 |
| 65 | 16 210 | 3173 | 19.8 (19.0 to 20.6) | |
| Sex: | | | | |
| Men | 26 313 | 3073 | 10.2 (9.8 to 10.6) | 0.001 |
| Women | 31 873 | 3244 | 8.6 (8.2 to 9.0) | |
| Race/ethnicity: | | | | |
| Hispanic | 6651 | 778 | 13.4 (12.2 to 14.5) | |
| Non-Hispanic white | 40 779 | 4116 | 8.0 (7.7 to 8.4) | |
| Non-Hispanic black | 6214 | 945 | 13.1 (12.1 to 14.1) | 0.001 |
| Non-Hispanic Asian | 2819 | 239 | 8.9 (7.6 to 10.2) | |
| Other | 1609 | 228 | 13.7 (11.2 to 16.2) | |
| Education level: | | | | |
| Below high school | 5461 | 1061 | 14.9 (13.8 to 16.1) | |
| High school | 15 307 | 1932 | 10.4 (9.8 to 11.0) | 0.001 |
| Beyond high school | 37 220 | 3296 | 7.9 (7.6 to 8.3) | |
| Family income level (IPR): | | | | |
| 1.0 | 6574 | 941 | 15.2 (14.0 to 16.3) | |
| 1.0-1.9 | 8729 | 1234 | 13.1 (12.2 to 14.1) | |
| 2.0-3.9 | 14 024 | 1478 | 9.4 (8.8 to 10.0) | 0.001 |
| 4.0 | 19 342 | 1566 | 7.1 (6.6 to 7.5) | |
| BMI (kg/m² ): | | | | |
| 25.0 | 19 163 | 912 | 4.2 (3.8 to 4.5) | |
| 25.0-29.9 | 19 627 | 1845 | 7.8 (7.3 to 8.2) | 0.001 |
| 30.0 | 19 396 | 3560 | 15.6 (15.0 to 16.2) | |

BMI=body mass index; IPR=family income to poverty ratio.
*Unweighted number of participants and diabetes cases.
†All prevalence estimates were weighted. Overall and age group results were unadjusted, except when indicated otherwise. Results by other stratums were age adjusted to 2010 US census population using age groups 20-44 years, 45-64 years, and 65 years or older.
‡P value for overall differences across stratums.

Table 2 | Prevalence of diagnosed type 1 and type 2 diabetes among US adults in 2016 and 2017 (n=57 930)*

| Characteristics | Type 1 diabetes | | | | Type 2 diabetes | | | |
|---|---|---|---|---|---|---|---|---|
| | Prevalence, % (95% CI)† | P value‡ | % of diagnosed total diabetes (95% CI)† | P value‡ | Prevalence, % (95% CI)† | P value‡ | % of diagnosed total diabetes (95% CI)† | P value‡ |
| Overall | 0.5 (0.5 to 0.6) | | 5.6 (4.9 to 6.4) | | 8.5 (8.2 to 8.8) | | 91.2 (90.4 to 92.1) | |
| Age adjusted | 0.5 (0.5 to 0.6) | | 9.9 (8.1 to 11.7) | | 8.2 (7.9 to 8.5) | | 85.0 (83.1 to 86.9) | |
| Age (years): | | | | | | | | |
| 20-44 | 0.5 (0.3 to 0.6) | | 16.6 (12.8 to 20.4) | | 2.1 (1.8 to 2.3) | | 75.3 (71.1 to 79.4) | |
| 45-64 | 0.6 (0.4 to 0.7) | 0.14 | 4.6 (3.6 to 5.6) | 0.001 | 11.1 (10.5 to 11.7) | 0.001 | 92.4 (91.2 to 93.7) | 0.001 |
| 65 | 0.6 (0.5 to 0.8) | | 3.3 (2.6 to 4.1) | | 18.2 (17.4 to 19.0) | | 94.9 (94.1 to 95.8) | |
| Sex: | | | | | | | | |
| Men | 0.6 (0.5 to 0.7) | 0.12 | 11.0 (8.5 to 13.6) | 0.34 | 9.0 (8.6 to 9.4) | 0.001 | 86.0 (83.3 to 88.8) | 0.19 |
| Women | 0.5 (0.4 to 0.6) | | 8.9 (6.5 to 11.3) | | 7.5 (7.1 to 7.9) | | 84.0 (81.2 to 86.8) | |
| Race/ethnicity: | | | | | | | | |
| Hispanic | 0.5 (0.3 to 0.7) | | 4.3 (1.5 to 7.2) | | 11.8 (10.7 to 13.0) | | 90.0 (86.1 to 93.8) | |
| Non-Hispanic white | 0.6 (0.5 to 0.7) | | 15.3 (12.6 to 18.0) | | 7.0 (6.7 to 7.3) | | 79.8 (77.0 to 82.7) | |
| Non-Hispanic black | 0.4 (0.2 to 0.6) | 0.02 | 5.1 (1.9 to 8.3) | 0.001 | 11.7 (10.8 to 12.6) | 0.001 | 89.1 (84.7 to 93.5) | 0.001 |
| Non-Hispanic Asian | 0.2 (0.1 to 0.4) | | 1.8 (0.3 to 3.3) | | 8.1 (6.8 to 9.4) | | 91.9 (85.2 to 98.6) | |
| Other | 0.9 (0.3 to 1.4) | | 5.9 (1.4 to 10.5) | | 12.1 (9.8 to 14.4) | | 92.1 (86.8 to 97.5) | |
| Education: | | | | | | | | |
| Below high school | 0.6 (0.4 to 0.8) | | 4.7 (2.4 to 7.1) | | 12.7 (11.6 to 13.8) | | 89.0 (84.7 to 93.2) | |
| High school | 0.5 (0.3 to 0.6) | 0.02 | 8.8 (5.8 to 11.7) | 0.001 | 9.3 (8.8 to 9.9) | 0.001 | 87.7 (84.3 to 91.0) | 0.001 |
| Beyond high school | 0.5 (0.4 to 0.6) | | 11.7 (9.2 to 14.2) | | 7.0 (6.7 to 7.3) | | 82.6 (79.7 to 85.5) | |
| Family income (IPR): | | | | | | | | |
| 1.0 | 0.8 (0.5 to 1.0) | | 9.9 (5.8 to 14.0) | | 13.1 (12.0 to 14.2) | | 83.8 (78.9 to 88.7) | |
| 1.0-1.9 | 0.6 (0.4 to 0.8) | 0.60 | 6.5 (3.9 to 9.1) | 0.09 | 11.6 (10.7 to 12.5) | 0.001 | 88.5 (84.9 to 92.1) | 0.41 |
| 2.0-3.9 | 0.4 (0.3 to 0.5) | | 8.8 (5.7 to 11.8) | | 8.4 (7.9 to 9.0) | | 85.2 (81.1 to 89.3) | |
| 4.0 | 0.5 (0.4 to 0.7) | | 13.1 (9.5 to 16.7) | | 6.2 (5.8 to 6.6) | | 82.6 (78.8 to 86.4) | |
| BMI (kg/m²): | | | | | | | | |
| 25.0 | 0.5 (0.4 to 0.6) | | 27.1 (20.6 to 33.6) | | 3.3 (3.0 to 3.7) | | 67.1 (60.5 to 73.6) | |
| 25.0-29.9 | 0.6 (0.4 to 0.7) | 0.05 | 14.2 (10.0 to 18.4) | 0.001 | 6.7 (6.3 to 7.2) | 0.001 | 81.0 (76.4 to 85.6) | 0.001 |
| 30.0 | 0.5 (0.4 to 0.6) | | 4.1 (2.9 to 5.3) | | 14.1 (13.5 to 14.7) | | 90.8 (88.9 to 92.7) | |

BMI=body mass index; IPR=family income to poverty ratio.
*Unweight number of participants. Number of type 1 and type 2 diabetes cases was 345 and 5798, respectively. Participants who did not know subtypes (n=253) or refused to report subtypes (n=3) were excluded.
†All estimates were weighted. Overall and age group results were unadjusted, except when indicated otherwise. Results by other stratums were age adjusted to 2010 US census population using age groups 20-44 years, 45-64 years, and 65 years or older.
‡P value for overall differences across stratums.

other countries as well.[12 18 22-24] Although none of those US national surveys collected information on subtypes of diabetes, several previous studies used limited and indirect information from those surveys to estimate the prevalence of type 1 and type 2 diabetes among US adults.[25 26] For example, using data from the National Health and Nutrition Examination Survey, one study estimated the prevalence of type 1 diabetes in the entire civilian non-institutionalized US population, including adults and children, to be 2.6 per 1000 or 3.4 per 1000, depending on the working definitions.[25] In that study, however, type 1 diabetes was assumed on the basis of age when diabetes was diagnosed (<30 years, definition 1; or <40 years, definition 2), insulin use within one year of diagnosis, and current use of insulin.[25] Another study estimated the crude prevalence of type 2 diabetes, defined as a self reported physician diagnosis of diabetes after age 30 years, in US adults across race/ethnicity groups on the basis of the Behavioral Risk Factor Surveillance System.[26] The reported crude prevalence of type 2 diabetes was 9.4% among Hispanic people, 6.9% among non-Hispanic white people, 12.0% among non-Hispanic black people, and 5.0% among non-Hispanic Asian people. However, classification of diabetes subtypes simply by age of diabetes diagnosis (<30 years or <40 years)

could lead to bias, as previous studies have shown that type 2 diabetes accounted for 12% of all diabetes cases in people aged <30 years.[27] Moreover, a population based registry in Italy reported that the incidence of type 1 diabetes in adults aged 30-49 years was similar to that in those aged <30 years.[28]

Continued monitoring of the prevalence of type 1 and type 2 diabetes among adults is particularly important because both have increased substantially over time among children and adolescents.[22 29] In the United States, the SEARCH for Diabetes in Youth study reported that between 2001 and 2009 the prevalence of type 1 and type 2 diabetes among children and adolescents increased from 1.48 to 1.93 per 1000 and from 0.34 to 0.46 per 1000, respectively.[30] Moreover, among US children and adolescents during 2002-12 the annual incidence of type 1 and type 2 diabetes increased by 1.4% and 7.1%, respectively.[31] It was projected that among US children and adolescents, the number of cases of type 1 diabetes would nearly triple, from 179 388 in 2010 to 587 488 in 2050 and the number of cases of type 2 diabetes would almost quadruple, from 22 820 in 2010 to 84 131 in 2050.[32] As a result, cases of type 1 and type 2 diabetes in adults will substantially increase as the children and adolescents reach adulthood. Major risk factors for type 2 diabetes, including

Table 3 | Weighted logistic regression models for diagnosed type 1 and type 2 diabetes among US adults in 2016 and 2017 (n=57 930)*

| Characteristics | Type 1 diabetes | | Type 2 diabetes | |
|---|---|---|---|---|
| | Adjusted odds ratio (95% CI)† | P value | Adjusted odds ratio (95% CI)† | P value |
| Age (years): | | | | |
| 20-44 | 1.00 (reference) | | 1.00 (reference) | |
| 45-64 | 1.18 (0.85 to 1.65) | 0.32 | 0.77 (0.71 to 0.83) | 0.001 |
| 65 | 1.33 (0.92 to 1.93) | 0.13 | | |
| Sex: | | | 1.47 (1.28 to 1.69) | 0.001 |
| Men | 1.00 (reference) | | 1.00 (reference) | |
| Women | 0.76 (0.58 to 0.99) | 0.04 | 1.48 (1.32 to 1.66) | 0.001 |
| Race/ethnicity: | | | 1.76 (1.42 to 2.18) | 0.001 |
| Hispanic | 0.56 (0.32 to 0.97) | 0.04 | 1.72 (1.35 to 2.18) | 0.001 |
| Non-Hispanic white | 1.00 (reference) | | | |
| Non-Hispanic black | 0.64 (0.40 to 1.03) | 0.07 | 1.00 (reference) | |
| Non-Hispanic Asian | 0.34 (0.16 to 0.73) | 0.005 | 0.87 (0.77 to 0.98) | 0.02 |
| Other | 1.13 (0.59 to 2.17) | 0.71 | 0.75 (0.66 to 0.85) | 0.001 |
| Education: | | | | |
| Below high school | 1.00 (reference) | | 1.00 (reference) | |
| High school | 0.67 (0.44 to 1.03) | 0.07 | 0.90 (0.78 to 1.03) | 0.12 |
| Beyond high school | 0.78 (0.52 to 1.17) | 0.22 | 0.67 (0.58 to 0.77) | 0.001 |
| Family income (IPR): | | | 0.53 (0.46 to 0.61) | 0.001 |
| 1.0 | 1.00 (reference) | | | |
| 1.0-1.9 | 0.70 (0.43 to 1.14) | 0.15 | 1.00 (reference) | |
| 2.0-3.9 | 0.51 (0.32 to 0.79) | 0.003 | 2.08 (1.84 to 2.34) | 0.001 |
| 4.0 | 0.59 (0.40 to 0.89) | 0.01 | 5.01 (4.49 to 5.60) | 0.001 |
| BMI (kg/m²): | | | | |
| 25.0 | 1.00 (reference) | | 1.00 (reference) | |
| 25.0-29.9 | 1.04 (0.74 to 1.46) | 0.84 | 0.77 (0.71 to 0.83) | 0.001 |
| 30.0 | 0.95 (0.69 to 1.30) | 0.73 | 1.47 (1.28 to 1.69) | 0.001 |

BMI=body mass index; IPR=family income to poverty ratio.
*Unweighted sample size was 57 930 after excluding those who did not know subtypes (n=253) or refused to report subtypes (n=3).
†Adjusted for all characteristic variables in table.

obesity, physical inactivity, and unhealthy diets are still problematic and without a notable declining trend.[12] Although genetic disposition plays a critical part in type 1 diabetes, the potential role of environmental risk factors are increasingly recognized.[13 33]

However, dynamic changes in the proportions of type 1 and type 2 diabetes in diabetes overall are expected over time. Although type 2 diabetes is generally regarded to account for 90-95% of diabetes cases,[1] the International Diabetes Federation reported that approximately 87-91% of people with diabetes in high income countries have type 2 diabetes, 7-12% have type 1 diabetes, and 1-3% have other diabetes subtypes.[34] One study in the United States using medical claims data estimated that type 2 diabetes accounted for about 92% of cases of diabetes among insured US adults, although the results could not be generalized to the US population.[35] The proportion of type 2 diabetes in cases of diagnosed diabetes in the present study (91.2%), based on the most recent prevalence estimates in 2016 and 2017, was comparable to the previously reported prevalence. However, with the increases in prevalence[30] and incidence[31] of type 1 diabetes in young people, and improved treatment and extended life expectancy in those with this form of diabetes,[36-38] more adults with childhood onset type 1 diabetes will live with the condition across their lifespan. Future studies with continued surveillance are needed to examine this dynamic trend.

## Strengths and weaknesses of this study

The major strength of this study is the use of nationally representative data from a leading national health survey, such that the findings are representative of the US general population. In addition, the large sample size and diverse racial/ethnic population allowed us to investigate risk factors and disparities between populations with type 1 and type 2 diabetes. This study has several limitations. Firstly, information on physician diagnosis of diabetes was self reported by the participants and therefore prone to misreporting and recall bias. Previous studies, however, have shown the specificity of self reported diabetes to be more than 95% compared with physician's medical records[39] or a reference definition defined by plasma glucose level and drug use.[40] Secondly, we could not rule out the possibility of participants misreporting the subtypes of diabetes. However, some major clinical characteristics reported by the participants were in line with current knowledge of reported diabetes subtypes. For example, the weighted mean age of diabetes diagnosis for those with type 2 diabetes was 47.9 years, with 89.1% of participants given a diagnosis at age 30 years or older. Most of the participants with type 1 diabetes who used insulin had initiated use within one year of diagnosis. The weighted mean age at diagnosis of type 1 diabetes among the adult participants was 28.3 years old. Although type 1 diabetes is known as "juvenile diabetes," most people with type 1 diabetes are adults.[38 41 42] Recent epidemiologic studies also

showed that around half of the cases of type 1 diabetes was diagnosed after age 30 years.[42 43] Thirdly, this study focused on cases of diagnosed diabetes. We were unable to ascertain undiagnosed diabetes in this survey and therefore the prevalence of diabetes, including both diagnosed and undiagnosed cases, would be expected to be higher than reported in this study.

## Conclusions

This study provides benchmark estimates on the national prevalence of diagnosed type 1 and type 2 diabetes among US adults. Further investigations are warranted to understand the reasons for disparities in such prevalence among subpopulations. Continued monitoring is needed to examine dynamic changes in the prevalence of type 1 and type 2 diabetes and their proportions in people with a diagnosis of diabetes in the US general population. The role of changing patterns in risk factors on the national prevalence of type 1 and type 2 diabetes also needs to be determined.

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**Supplementary information:** figure showing flow of participants through study