RESEARCH LETTER

Prevalence of Diabetes in Adolescents Aged 12 to 19 Years in the United States, 2005-2014

Few data are available on the prevalence of diabetes among adolescents in the United States, particularly the percentage of those undiagnosed.1-3 The objective of this study was to estimate the prevalence of diabetes, the percentage of those who were unaware of their diabetes, and the prediabetes prevalence among adolescents using nationally representative data.

Methods | The National Health and Nutrition Examination Survey (NHANES) is a series of 2-year stratified, multistage probability surveys representative of the civilian, noninstitutionalized US population, which include in-person interviews and examinations in mobile centers.3 We used data from 2005-2014 (in which all relevant glucose data were available) from adolescents aged 12 to 19 years who were randomly selected for the morning examination session after fasting. The response rate among adolescents was 83% for the interview and 81% for the examination. Written informed consent was obtained from participants aged 12 to 19 years; among participants aged 12 to 17 years, written assent was obtained and written informed consent from parents/guardians. The research ethics boards of the National Center for Health Statistics approved all protocols.

A questionnaire was used to collect demographic information.3 Participants were asked if they had ever been diagnosed with diabetes by a “doctor or other health professional.” Hemoglobin A1c and fasting plasma glucose (FPG) were measured and FPG was calibrated over time.3 An oral glucose tolerance test was administered using 75 g of glucose, followed by venipuncture to measure 2-hour plasma glucose (2HPG). Diabetes was defined as a previous diagnosis, a hemoglobin A1c level of 6.5% or more, an FPG level of 126 mg/dL or more, or a 2HPG level of 200 mg/dL or more (to convert glucose to mmol/L, multiply by 0.0555). Prediabetes was defined as not having diabetes and having a hemoglobin A1c level of 5.7% to 6.4%, an FPG level of 100 mg/dL to 125 mg/dL, or a 2HPG level of 140 mg/dL to 199 mg/dL.

The diabetes prevalence, the percentage that was undiagnosed (ie, unaware of their condition), and the prediabetes prevalence overall and stratified by sex and race/ethnicity were calculated. A regression model with diabetes as the outcome and time as the predictor was used to assess trends over time. Two-sided P values less than .05 were considered statistically significant.

Sample weights accounting for unequal selection probabilities and nonresponse produced results representative of the total civilian noninstitutionalized US population.4 Data were analyzed using SUDAAN (RTI International), version 10.0.1.

Results | Of 2606 adolescents included, 62 had diabetes, 20 were undiagnosed, and 512 had prediabetes. The weighted prevalence of diabetes was 0.8% (95% CI, 0.6%-1.1%), of which 28.5% (95% CI, 16.4%-44.8%) was undiagnosed, and the prevalence of prediabetes was 17.7% (95% CI, 15.8%-19.8%) (Table). Prediabetes was more common in males (22.0% [95% CI, 19.5%-24.7%]) than females (13.2% [95% CI, 10.4%-16.7%]). Compared with non-Hispanic white participants, the percentage of adolescents with diabetes who were undiagnosed (4.6% [95% CI, 0.6%-28.5%]) and the prediabetes prevalence (15.1% [95% CI, 12.3%-18.6%]) were higher in non-Hispanic black participants (49.9% [95% CI, 25.9%-73.8%] and 21.0% [95% CI, 17.7%-24.7%], respectively) and Hispanic participants (39.5% [95% CI, 19.8%-63.3%] and 22.9% [95% CI, 19.9%-26.3%], respectively). Diabetes (P = .44) and prediabetes (P = .44) prevalences did not change over time.

Discussion | To our knowledge, these are the first estimates of diabetes in a nationally representative sample of US adolescents using all 3 American Diabetes Association (ADA) recommended biomarkers (hemoglobin A1c, FPG, and 2HPG).1-2 The estimates are higher than previously reported; 1 study found diagnosed diabetes in 0.34% of participants aged 10 to 19 years.3 A relatively large proportion was unaware of the condition, particularly among non-Hispanic black participants and Hispanic participants, indicating a need for improved diabetes screening among adolescents. These findings may have important public health implications because diabetes in youth is associated with early onset of risk factors and complications.5,6

Study limitations include ascertaining previous diagnosis by self-report. The ADA recommends a repeat measurement after a single positive test using hemoglobin A1c, FPG, or 2HPG, but NHANES does not repeat such measurements. These issues may result in an overestimation of diabetes prevalence. We could not distinguish type of diabetes, but previous research in adolescents found 87% had type 1.1 NHANES has unique strengths including a nationally representative sample and the ability to estimate undiagnosed diabetes.

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Author Contributions: Dr Cowie had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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Table. Weighted Diabetes Prevalence Using Self-reported Previous Diagnosis, Hemoglobin A1c, Fasting Plasma Glucose (FPG), and 2-Hour Plasma Glucose (2HPG) to Determine Diabetes Status Among Adolescents Aged 12 to 19 Years in the US Population, 2005-2014

<table>
<thead>
<tr>
<th>Race/ethnicity</th>
<th>Total Diabetes, % (95% CI)</th>
<th>Undiagnosed*</th>
<th>Prediabetes*</th>
<th>P Value</th>
<th>Prediabetes*</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall (N = 2606)</td>
<td>0.80 (0.57-1.12)</td>
<td>28.5 (16.4-44.8)</td>
<td>17.7 (15.8-19.8)</td>
<td></td>
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</tr>
<tr>
<td>Sex</td>
<td></td>
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<tr>
<td>Males (n = 1374)</td>
<td>0.97 (0.61-1.55)</td>
<td>25.5 (12.9-44.0)</td>
<td>Reference</td>
<td>22.0 (19.5-24.7)</td>
<td>Reference</td>
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</tr>
<tr>
<td>Females (n = 1232)</td>
<td>0.61 (0.34-1.10)</td>
<td>33.5 (12.8-61.4)</td>
<td>.75</td>
<td>13.2 (10.4-16.7)</td>
<td>&lt;.001</td>
<td></td>
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<tr>
<td>Race/ethnicity</td>
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<tr>
<td>Non-Hispanic</td>
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<tr>
<td>White (n = 710)</td>
<td>0.60 (0.31-1.17)</td>
<td>4.6 (0.6-28.5)</td>
<td>Reference</td>
<td>15.1 (12.3-18.6)</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>Black (n = 716)</td>
<td>1.52 (0.97-2.38)</td>
<td>49.9 (25.9-73.8)</td>
<td>.03</td>
<td>21.0 (17.7-24.7)</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>All Hispanic (n = 953)</td>
<td>0.76 (0.46-1.25)</td>
<td>39.5 (19.8-63.3)</td>
<td>.04</td>
<td>22.9 (19.9-26.3)</td>
<td>.005</td>
<td></td>
</tr>
<tr>
<td>Mexican-American (n = 729)</td>
<td>0.85 (0.48-1.51)</td>
<td>43.9 (20.6-70.2)</td>
<td>.01</td>
<td>22.4 (18.9-26.4)</td>
<td>.001</td>
<td></td>
</tr>
</tbody>
</table>

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

* The percentage of total diabetes that was undiagnosed. Undiagnosed diabetes was based on no report of previous diagnosis and having a hemoglobin A1c level of 6.5% or more, FPG level of 126 mg/dL or more, or 2HPG level of 200 mg/dL or more.

* Prediabetes was based on hemoglobin A1c level of 5.7%-6.4%, FPG level of 100-125 mg/dL, or 2HPG level of 140-199 mg/dL (and does not have diagnosed or undiagnosed diabetes).

± Relative standard error more than 30% indicating the estimate has low precision.

† Race/ethnicity was self-reported in response to questions with fixed categories so that prevalence estimates of major diseases such as diabetes could be reported stratified by race/ethnicity. Too few participants self-reporting other race/ethnic groups were available for statistical analysis as a separate group; they were included in other data presented in the Table.

COMMENT & RESPONSE

Outcome After Admission at Veterans Affairs vs Non–Veterans Affairs Hospitals

To the Editor Mr Nuti and colleagues reported that hospitalization at Veterans Affairs (VA) hospitals, compared with non-VA hospitals, was associated with lower 30-day all-cause mortality for older men with acute myocardial infarction or heart failure, but higher 30-day readmission rates for acute myocardial infarction, heart failure, or pneumonia.1 Our question focuses on the study’s method of risk adjustment—specifically, whether the authors’ method fully accounts for the burden of comorbid illness among veterans admitted to VA hospitals. It is unclear whether the authors incorporated both VA and Medicare claims, or Medicare claims alone, to identify comorbid conditions for veterans in their risk-adjustment models.

For VA beneficiaries who are dually enrolled in Medicare, comorbidity codes should be identified from both VA and Medicare claims to accurately capture comorbid conditions.2,3 Using only Medicare claims to risk adjust would capture a fraction of conditions, thus skewing the results in favor of hospitalization outside the VA (ie, giving the appearance that VA hospitalizations involve patients with less severe comorbid disease). Moreover, if the study only included comorbidities coded within Medicare, this would systematically exclude conditions that are predominantly treated within the VA and have an important effect on mortality and readmission, such as mental illness and substance abuse.4

Risk adjustment using diagnoses documented in both the VA and Medicare would be an improvement over using codes from only one system. However, the issue of systemic under-coding of conditions within the VA compared with Medicare...