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Trends in type 2 diabetes detection among adults in the USA, 1999–2014

Linda S Geiss,[1] Kai McKeever Bullard,[1] Ralph Brinks,[2] Annika Hoyer,[2] Edward W Gregg[1]

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ABSTRACT

Objective To examine recent trends in type 2 diabetes detection among adults in the USA.

Research design and methods We used data from the 1999–2014 National Health and Nutrition Examination Surveys on non-pregnant adults (aged ≥18 years) not reporting a diagnosis of diabetes (n=16 644 participants, averaging about 2000 for each 2-year cycle). We defined undiagnosed diabetes as a fasting plasma glucose ≥126 mg/dL or a hemoglobin A1c ≥6.5% (48 mmol/mol). We measured case detection as the probability of finding undiagnosed type 2 diabetes among the population without diagnosed diabetes. Linear regression models were used to examine trends overall and by sociodemographic characteristics (ie, age, gender, race/ethnicity, education, poverty-income ratio (PIR)).

Results Age-standardized probability of finding undiagnosed type 2 diabetes was 3.0% (95% CI 2.1% to 4.2%) during 1999–2000 and 2.8% (2.2%–3.6%) during 2013–2014 (*P* for trend=0.52). Probability increased among Mexican-Americans (*P* for trend=0.01) but decreased among adults aged 65 years or older (*P* for trend=0.04), non-Hispanic (NH) white (*P* for trend=0.02), and adults in the highest PIR tertile (*P* for trend=0.047). For all other sociodemographic groups, no significant trends were detected.

Conclusions We found little evidence of increased detection of undiagnosed type 2 diabetes among adults in the USA during the past 15 years. Although improvements were seen among NH white, older, and wealthy adults, these improvements were not large. As the scope of primary prevention efforts increases, case detection may improve.

Significance of this study

What is already known about this subject?

- Because the proportion of diabetes cases that are undiagnosed can be a misleading index of case detection, a new metric has been proposed to monitor type 2 diabetes case detection—the probability of finding undiagnosed type 2 diabetes among the population *without* diagnosed diabetes.

What are the new findings?

- Although small improvements were seen in some advantaged population subgroups (non-Hispanic (NH) whites, adults aged 65 year or older, and higher income adults), our study found little evidence of increased detection of type 2 diabetes among adults in the USA during the past 15 years.

How might these results change the focus of research or clinical practice?

- Efforts to increase type 2 diabetes detection could benefit by focusing on Mexican-Americans and NH blacks, adults younger than 65 years of age, and those with lower incomes.

INTRODUCTION

Type 2 diabetes often goes undiagnosed for years among adults in the USA. This period is a missed opportunity to initiate evidence-based interventions to prevent complications from diabetes. As a result, the importance of surveillance in tracking case detection in the USA has been heightened. Although case detection is defined as the extent to which incident cases are detected (ie, number of new cases detected/true number of new cases), its measurement is impractical for diabetes because the true number of new cases is almost always unknown.[1] Previous studies[2–4] have assessed trends in diabetes case detection indirectly by estimating the proportion of diabetes cases that are undiagnosed (ie, undiagnosed prevalent cases/diagnosed and undiagnosed diabetes prevalent cases). However, a recent simulation study[5] comparing the performance of prevalence-based and incidence-based measures to assess case detection demonstrated that incidence measures are superior to prevalence measures, and that the proportion of diabetes cases that are diagnosed (or the inverse, undiagnosed) can be a misleading index of case detection. Instead, the authors recommend that if only prevalence data are available to assess case detection, then the probability of finding undiagnosed diabetes among the population *without* diagnosed diabetes would be a more appropriate way of measuring success. The objective of the current study is to examine national trends and disparities in type 2 diabetes detection in the USA by using the newly recommended measure: the

[1]Division of Diabetes Translation, Centers for Disease Control and Prevention, Atlanta, Georgia, USA
[2]Institute for Biometry and Epidemiology, German Diabetes Center, Dusseldorf, Germany

Correspondence to
Dr Kai McKeever Bullard; hjo1@cdc.gov

probability of finding undiagnosed diabetes among the population without diagnosed diabetes.

RESEARCH DESIGN AND METHODS

Data source

We used data from the 1999–2014 National Health and Nutrition Examination Surveys (NHANES) conducted by the National Center for Health Statistics (NCHS), Centers for Disease Control and Prevention. NHANES is an ongoing cross-sectional survey of the health and nutritional status of the non-institutionalized US civilian population, and its data are released in 2-ear increments. NHANES participants are selected through a complex, multistage cluster sampling design.[6] Data are collected through interviews in participants' homes and biological samples using standardized measurements in a mobile examination center. The NCHS institutional review board approved the survey protocol, and written informed consent was obtained from all participants aged 18 years or older. Response rates for completing the interview and examination for the NHANES cycles during 1999–2014 ranged from 68.5% to 80.0%.[7]

Study participants

We included NHANES adult participants (aged ≥18 years) from the morning examination session who had fasted 8 hours to less than 24 hours, excluding those reporting a previous diagnosis of diabetes (a negative response to the question: were you ever told by a doctor or health professional that you have diabetes?) (n=1901) and pregnant women (n=602). The final analytic sample included 16 644 participants, averaging about 2000 for each 2-year cycle.

Measurements and definitions

Our measure of case detection was the probability of finding an undiagnosed case of type 2 diabetes among the population without diagnosed diabetes (ie, number of undiagnosed prevalent cases/population without diagnosed diabetes).[5] A high value of this measure indicates poor detection, and a decreasing trend in this measure would indicate improvements in detection. We defined undiagnosed diabetes as a fasting plasma glucose (FPG) level of 126 mg/dL or higher, or a hemoglobin A1c level of 6.5% (48 mmol/mol) or higher. We categorized self-reported sociodemographic data as follows: age (18–44, 45–64, ≥65 years), sex (men, women), race or ethnicity (non-Hispanic (NH) white, NH black, Mexican-American, and other racial or ethnic groups), education level (<high school, high school, and >high school), and survey cycle-specific tertile of poverty-income ratio (PIR). PIR is defined as the ratio of the individual's family income to their poverty threshold as defined by the US Census Bureau, accounting for inflation and family size.[7]

Statistical analysis

By using appropriate fasting sampling weights and sampling design information, we calculated nationally

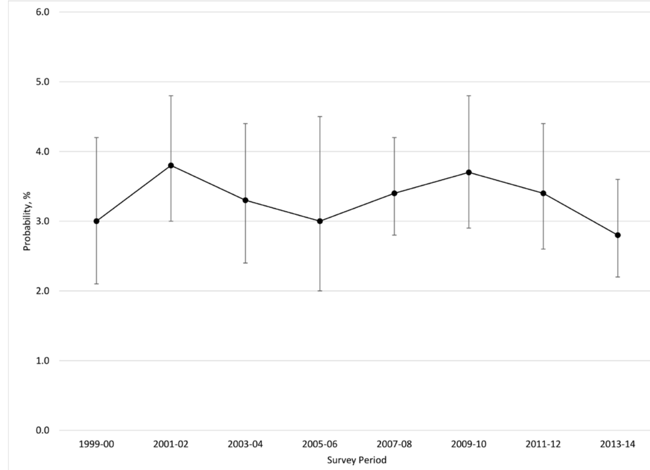

Figure 1 Age-standardized probability of finding undiagnosed diabetes among the US population without diagnosed diabetes aged ≥18 years by survey cycle. National Health and Nutrition Examination Surveys 1999–2014. *P* for trend=0.52, calculated from a linear regression model by using variance weighted least squares with 2-year survey cycle as the independent variable.

representative estimates of our surrogate prevalence measure of detection–the probability of finding undiagnosed diabetes. We stratified probability estimates by sociodemographic characteristics. To produce reliable estimates by demographic subgroups, we grouped NHANES data into 4-year periods: 1999–2002, 2003–2006, 2007–2010, and 2011–2014. Age-standardized prevalences were calculated by using the direct method applied to the 2000 US census population with our three age groups. To assess trends, we estimated the probabilities of finding undiagnosed diabetes for each 2-year survey cycle and calculated *P* for trend from linear regression models using variance weighted least squares with 2-year survey cycle as the independent variable. A *P* value of less than 0.05 was considered statistically significant.

RESULTS

In the USA, the age-standardized probability of finding undiagnosed type 2 diabetes among adults without diagnosed diabetes was 3.0% (95% CI 2.1% to 4.2%) during 1999–2000 and 2.8% (2.2%–3.6%) during 2013–2014 (figure 1) (*P* for trend=0.52). When time trends were examined by sociodemographic subgroups (table 1), a significant increase was found among Mexican-Americans, for whom the probability increased from 3.7% (2.4%–5.5%) during 1999–2002 to 6.0% (4.0%–8.9%) during 2011–2014 (*P* for trend=0.01). During 1999–2014, significant decreases occurred for adults aged 65 years or older (*P* for trend=0.04), NH white (*P* for trend=0.02), and adults in the highest PIR tertile (*P* for trend=0.047). However, differences between first and last periods were not great. For all other sociodemographic groups, there were no significant trends.

Table 1 Probability (percentage, 95% CI) of finding undiagnosed diabetes among the US population without diagnosed diabetes aged ≥18 years, National Health and Nutrition Examination Surveys (NHANES), 1999–2014*

	1999–2002	2003–2006	2007–2010	2011–2014	
	n=3974	n=3778	n=4562	n=4330	P value †
Crude estimates					
Total	3.3 (2.8–4.0)	3.2 (2.5–4.0)	3.7 (3.1–4.3)	3.2 (2.7–3.8)	0.83
Age group (years)					
18–44	1.2 (0.6–2.1)	1.1 (0.6–1.8)	1.1 (0.7–1.5)	1.3 (0.9–2.0)	0.91
45–64	5.0 (3.6–6.7)	3.9 (2.6–5.7)	4.4 (3.2–5.9)	4.9 (3.8–6.3)	0.60
≥65	7.8 (5.9–10.4)	8.9 (6.5–12.2)	10.9 (8.6–13.7)	5.6 (3.9–7.9)	0.04
Age-standardized estimates ‡					
Total	3.4 (2.9–4.1)	3.3 (2.6–4.1)	3.7 (3.2–4.4)	3.1 (2.6–3.8)	0.52
Sex					
Men	4.2 (3.3–5.2)	4.4 (3.3–5.8)	5.0 (4.1–6.1)	3.7 (2.8–5.0)	0.39
Women	2.9 (2.2–3.7)	2.2 (1.5–3.1)	2.6 (2.0–3.4)	2.6 (2.0–3.4)	0.63
Race/ethnicity§					
Non-Hispanic white	3.2 (2.6–3.9)	2.9 (2.1–4.1)	3.1 (2.5–3.7)	2.2 (1.7–2.9)	0.02
Non-Hispanic black	5.3 (3.9–7.3)	4.6 (3.6–5.7)	6.5 (5.1–8.3)	5.5 (3.9–7.6)	0.50
Mexican-American	3.7 (2.4–5.5)	4.7 (3.5–6.3)	7.0 (5.0–9.6)	6.0 (4.0–8.9)	0.01
Education					
<High school	5.5 (4.3–7.1)	4.2 (3.0–6.0)	4.5 (3.6–5.6)	4.9 (3.6–6.7)	0.96
High school graduate	3.2 (2.2–4.7)	4.3 (3.0–6.1)	5.3 (4.0–7.0)	3.7 (2.9–4.9)	0.69
>High school	2.6 (1.9–3.6)	2.5 (1.7–3.5)	2.7 (2.0–3.5)	2.4 (1.8–3.3)	0.92
Poverty-income ratio tertile¶					
Lowest	4.7 (3.6–6.3)	4.1 (3.2–5.3)	4.0 (3.2–5.1)	4.6 (3.7–5.8)	0.83
Middle	3.3 (2.3–4.7)	3.3 (2.1–5.2)	3.9 (2.9–5.3)	3.0 (2.2–4.3)	0.69
Highest	2.4 (1.7–3.5)	1.8 (0.9–3.4)	3.2 (2.3–4.4)	1.5 (0.9–2.5)	<0.05

*Two NHANES cycles were combined, yielding more precise, 4-year prevalence estimates.
†*P* values for trend were estimated from linear regression models by using variance weighted least squares with 2-year survey cycle as the independent variable.
‡Prevalence estimates were age-standardized to the 2000 US standard population by using age groups 18–44, 45–64, and ≥65 years.
§Prevalence estimates for participants who self-reported as other race/ethnicity were not presented because of small numbers, but their data are included in other estimates.
¶Data on poverty-income ratio were missing for 1292 participants.

During 2011–2014, the probability of finding undiagnosed type 2 diabetes was lower among adults aged 18–44 years (1.3%, 0.9%–2.0%) than among adults aged 65 years or older (5.6%, 3.9%–7.9%); higher among men (3.7%, 2.8%–5.0%) than women (2.6%, 2.0%–3.4%); higher among NH black adults (5.5%, 3.9%–7.6%) and Mexican-Americans (6.0%, 4.0%–8.9%) than among NH white adults (2.2%, 1.7%–2.9%); higher among those with less than a high school education (4.9%, 3.6%–6.7%) than among those with greater than a high school education (2.4%, 1.8%–3.3%); and higher in the lowest tertile of PIR (4.6%, 3.7%–5.8%) than the middle (3.0%, 2.2%–4.3%) and highest (1.5%, 0.9%–2.5%) tertiles.

DISCUSSION

Our analyses of nationally representative data suggest that detection of undiagnosed type 2 diabetes among adults did not increase in the USA from 1999 to 2014. Although not increasing overall, detection improved among some sociodemographic subgroups in the USA, including NH white adults, adults in the highest income category (ie, in the top tertile of PIR), and those aged 65 years or older. Detection did not improve among other population subgroups, including black adults, adults of lower income (first and middle tertiles of PIR), and adults aged younger than 65 years. Further, we found that detection of type 2 diabetes decreased among Mexican-Americans. These findings stand in contrast to impressions that we are now doing a better job of detecting diabetes, and our findings suggest that this is only true for some sociodemographic groups.

Our findings of improved detection among select sociodemographic groups might be caused by increasing rates of testing for diabetes among those with access to healthcare. This is consistent with two cross-sectional studies[8 9] of NHANES data that found various measures of access to healthcare (eg, no health insurance or discontinuous insurance during the past year, no routine place for care, no healthcare during the past year) to be associated with having undetected diabetes.

Our study is the first to use a recently recommended metric[5]—the probability of finding undiagnosed diabetes among the population without diagnosed diabetes—to assess type 2 diabetes detection in the USA. The exclusion of diagnosed cases from the denominator is logical when assessing detection because diagnosed cases have already been detected and, therefore, need not be included among the population of interest. Further, this exclusion of diagnosed cases from the population of interest allows us to state what proportion of the population would test positive if those without known disease were tested. Thus, during 2011–2014, 3.2% of the population without diagnosed diabetes would test positive for diabetes or, alternatively, about 3 of 100 adults would be found to have type 2 diabetes.

In general, our findings are consistent with those of a study by Menke and colleagues,[3] which examined trends in the prevalence of undiagnosed type 2 diabetes (undiagnosed diabetes/total population) on the basis of NHANES data from an earlier period (ie, 1988–2012). Both of our studies found no significant increase in undiagnosed/undetected diabetes and similar sociodemographic disparities in prevalence. Both also found that undiagnosed diabetes increased among Mexican-Americans. However, in contrast to Menke and colleagues, our study found increased detection among NH white adults, adults in the highest income category, and those aged 65 years or older. These differences between studies may be related to the different periods studied or methods used in analyzing trends.

Prior research has shown that the proportion of diabetes that is undiagnosed (undiagnosed diabetes/diagnosed and undiagnosed diabetes) has decreased.[3 4] This trend has been interpreted as possible evidence of improved screening and detection.[2–4] Our finding of no overall improvements in type 2 diabetes detection and Menke and colleagues' finding of no declines in the prevalence of undiagnosed diabetes contradict these interpretations and point to the fallibility—as a recent study suggested[5]—of using the proportion of diabetes that is undiagnosed to monitor changes in detection over time.

The strengths of this study rest in its use of nationally representative survey data and appropriate statistical analyses that account for sampling design of survey and survey non-response. However, there are some limitations. To determine cases of undiagnosed type 2 diabetes, we relied on self-reported history of diabetes (with those reporting no history of diabetes receiving laboratory tests) and an A1c or FPG level indicative of diabetes. The less than perfect sensitivity of self-reported diabetes and the reliance on a single positive laboratory test to identify undiagnosed disease may lead to overestimation of undiagnosed diabetes prevalence.[10] Also, we do not know whether self-report of diabetes improved over time. Further, it is unknown how the introduction of A1c to diagnose diabetes may have affected trends, how physicians actually diagnose diabetes, and whether that has changed over time. These factors could impact trends and characteristics of persons diagnosed and undiagnosed.

In conclusion, despite clinical and public health aspirations of improving detection of type 2 diabetes and impressions that we may be doing a better job of detecting diabetes,[2–4] our study found little evidence of increased detection of type 2 diabetes among adults in the USA during the past 15 years. Exceptions where detection improved include adults of Medicare age, higher income adults, and NH white adults, all of whom may have better or more frequent access to healthcare, increasing their chances of being tested for diabetes or of opportunistic identification of undiagnosed diabetes. As additional prevention efforts are made to identity those at high risk of developing diabetes, case identification of undiagnosed type 2 diabetes may improve.

Contributors LSG participated in the study design, and drafted and revised the manuscript. KMB acquired and analysed the data, contributed to study design and critically reviewed the paper. RB, AH, EWG participated in the concept and design of the manuscript, critically reviewed and edited the manuscript, and contributed to the discussion. All authors approved the final version. LSG and KMB are the guarantors of this work and, as such, had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Disclaimer The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Competing interests None declared.

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Data sharing statement Not relevant as all data for this research were freely downloaded from the NCHS NHANES website at https://www.cdc.gov/nchs/nhanes/nhanes_questionnaires.htm.

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