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Factors Associated with Undiagnosed Diabetes among Adults with Diabetes: Results from the Hispanic Community Health Study/Study of Latinos (HCHS/SOL)

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Abstract

Aims: To investigate sociodemographic and health factors associated with undiagnosed diabetes among adults with diabetes in the Hispanic Community Health Study/Study of Latinos (HCHS/SOL).

Methods: Among 3,384 adults with self-reported diabetes or undiagnosed diabetes in the baseline HCHS/SOL, we estimated odds ratios (OR) of being undiagnosed for demographic, cultural, access to care, and health factors.

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Results: Among individuals with diabetes, 37.0% were undiagnosed. After adjustment and compared to people of Mexican heritage, people of Cuban and South American heritage had 60% (OR=1.60, 95% CI=1.02-2.50) and 91% (OR=1.91, 1.16-3.14) higher odds of being undiagnosed, respectively. Individuals with a higher odds of being undiagnosed were women (OR=1.64, 1.26-2.13), those with no health insurance (OR=1.31, 1.00-1.71), individuals who received no healthcare in the past year (OR=3.59, 2.49-5.16), those who were overweight (vs. normal weight) (OR=1.60, 1.02-2.50), and those with dyslipidemia (OR=1.38, 1.10-1.74). Individuals with lower odds of being undiagnosed were those with a family history of diabetes (OR=0.54, 0.43-0.68), and those with hypertension (OR=0.46, 0.36-0.58).

Conclusions: Variation by Hispanic heritage group, sex, and access to medical care highlight where concentrated efforts are need to improve diabetes awareness. Our findings will inform clinical and public health practices to improve diabetes awareness among vulnerable populations.

Keywords

Undiagnosed diabetes; Hispanic/Latinos; Hispanic Community Health Study/Study of Latinos

Introduction

During the development of type 2 diabetes, there is a latent period where hyperglycemia is sufficient to cause pathologic and functional changes which can lead to micro- and macro-vascular complications years before the appearance of clinical symptoms (1). There are effective treatments for diabetes that reduce the risk of complications, but patients who are never diagnosed cannot utilize these treatments (2, 3). Screening is not routine for all asymptomatic people in the general population, and even among people who meet screening criteria for diabetes by the American Diabetes Association (ADA), less than half reported diabetes screening in the previous three years (4). As a result, many people with diabetes are undiagnosed. In the United States in 2011-2012, 48% of Mexican Americans with diabetes were undiagnosed compared to 32% of non-Hispanic whites (5). In an analysis of the Hispanic Community Health Study/Study of Latinos (HCHS/SOL), a cohort of diverse Hispanic/Latino heritage groups, 34% of participants with diabetes were undiagnosed (6).

People with undiagnosed diabetes have an increased prevalence of diabetes-related morbidity and complications. Data from the National Health and Nutrition Examination Survey (NHANES) indicated that, in the total U.S. population, the prevalence of obesity, low HDL cholesterol, high blood pressure, retinopathy, and history of cardiovascular disease (CVD) were higher among those with undiagnosed diabetes compared to those with normal glucose levels (7). In addition, another study in the total U.S. population found that the onset of detectable retinopathy occurred an average of 4-7 years before diagnosis of diabetes (8). The HCHS/SOL cohort of diverse Hispanic/Latino heritage groups found that, compared to those with normal glucose, individuals with undiagnosed diabetes were more likely to be obese and to have hypertension, low HDL cholesterol, high triglycerides, and high urine albumin-creatinine ratio (9). The burden of undiagnosed diabetes and its associated complications in Hispanic/Latinos may contribute to the overall higher prevalence of complications in this group, compared to non-Hispanic whites. In the total U.S. population, prevalence of end stage renal disease and retinopathy were greater in Hispanics compared to

non-Hispanic whites with diabetes (10, 11). A previous review article found that Hispanics/Latinos had a higher mortality rate compared to the total U.S. population, with excess mortality partially attributed to diabetes (12). The risk of complications is likely to increase the longer diabetes is undiagnosed, thus, identifying predictors of undiagnosed diabetes is important, especially in high risk populations.

Few studies have investigated what factors are associated with undiagnosed diabetes particularly among U.S. Hispanics/Latinos. Undiagnosed diabetes among Hispanics/Latinos may be due to challenges in health care access, health literacy, cultural barriers, and being underinsured (13, 14). In an analysis of data from the 2011-2014 NHANES, which included a representative sample of the U.S. population including Hispanics, people who received no healthcare in the past year were more likely to be undiagnosed, while people with a family history of diabetes and those with a hospitalization in the previous year were less likely to be undiagnosed (15). This previous study also found that Hispanic/Latino women were more likely than women of other race/ethnicities to be undiagnosed. In addition, Mexican Americans and those with higher body mass index (BMI) levels were more likely to be undiagnosed than non-Hispanic whites and those with lower levels of BMI. Although the NHANES is a nationally representative and ethnically diverse study, the majority of Hispanic/Latinos in NHANES are of Mexican heritage. An improved understanding of which Hispanic/Latino heritage groups are more likely to be undiagnosed may lead to more efficient screening, improved awareness of diabetes, and overall better treatment for diabetes in these groups.

Our objective was to investigate which factors were associated with undiagnosed diabetes among adults with diagnosed and undiagnosed diabetes in the diverse Hispanic/Latino heritage groups from the HCHS/SOL. We investigated factors that we previously found in NHANES to be associated with undiagnosed diabetes in the total U.S. population, including factors related to access to care, family history of diabetes, and additional demographic, cultural, and health factors (15).

Subjects, Materials, and Methods

Study Population

HCHS/SOL is a community-based, prospective cohort study of self-identified Hispanic/Latino persons 18-74 years of age; Hispanic heritage groups included Dominican, Central American, Cuban, Mexican American, Puerto Rican, South American, and other/more than one heritage group (16). Participants were recruited from multistage probability sampling of four communities including Chicago, IL; Miami, FL; Bronx, NY; and San Diego, CA (17). For our analysis, we used baseline data collected between 2008 and 2011. Of the 16,415 total participants in the HCHS/SOL baseline examination, we included 3,384 with diagnosed or undiagnosed diabetes in our analysis. The Institutional Review Boards at the coordinating center and each of the field centers approved the study. All participants gave written informed consent.

Data Collection

Standardized questionnaires obtained self-reported information regarding age, Hispanic/Latino heritage, sex, family history of diabetes, education, household income, employment status, health insurance, healthcare in the past year, participants' perception of limited access to healthcare, nativity (born in one of the 50 U.S. states or District of Columbia or elsewhere), years lived in the US, languages spoken (Spanish and/or English), smoking status, work time activity level, and leisure time activity level. Height and weight were measured and BMI was calculated as weight in kilograms divided by height in meters squared. Blood pressure was measured three times using an automated sphygmomanometer after the participant rested quietly for 5 minutes in a sitting position; readings were taken 30 seconds apart. Hypertension was defined as an average systolic blood pressure ≥ 140 mm Hg, an average diastolic blood pressure ≥ 90 mm Hg, or use of blood pressure lowering medication. High-density lipoprotein (HDL) cholesterol and triglycerides were measured and low-density lipoprotein (LDL) cholesterol was estimated using the Friedewald equation (18). Dyslipidemia was defined as LDL cholesterol ≥ 160 mg/dL, HDL cholesterol <40 mg/dL, or triglycerides ≥ 200 mg/dL.

A1c was measured using a Tosoh G7 Automated HPLC Analyzer (Tosoh Medics, Inc., San Francisco, CA). Plasma glucose was measured after an overnight fast and again after a 75-g 2-hour oral glucose tolerance test using a Roche Modular P Chemistry Analyzer (Roche Diagnostics Corporation, Indianapolis, IN). People were considered to have undiagnosed diabetes if they reported no previous diabetes diagnosis by a doctor, but had undiagnosed diabetes based on American Diabetes Association criteria including an HbA1c $\geq 6.5\%$ (48 mmol/mol), a fasting plasma glucose ≥ 126 mg/dL, or a two-hour post-glucose load plasma glucose ≥ 200 mg/dL (1). Individuals had self-reported diagnosed diabetes if they reported a previous diabetes diagnosis by a doctor.

Statistical Methods

The distributions (percent, standard error) of participant characteristics were examined by self-reported diabetes (Table 1). The percentage of participants who were undiagnosed was determined overall and stratified by age, Hispanic/Latino heritage, and sex. Using logistic regression, we calculated unadjusted and multivariable adjusted odds ratios of being undiagnosed associated with the following participant characteristics: age [18-44 (reference), 45-64, 65-74 years], Hispanic/Latino heritage [Dominican, Central American, Cuban, Mexican American (reference), Puerto Rican, South American], sex [women vs. men (reference)], family history of diabetes (vs. no family history), education [less than high school, high school, more than high school (reference)], household income [$< \$10,000$, $\$10,000$ - $\$19,999$, $\$20,000$ - $\$39,999$, $\$40,000$ - $\$74,999$, $\geq \$75,000$ (reference), unknown], no health insurance (vs. health insurance), healthcare in the past year [in the U.S. (reference), in another country, none], self-reported perception of limited access to healthcare (vs. no limited access), years living in the U.S. [1-2, 3-5, 6-10, 11-15, >15 , U.S. born (reference)], only speaking/reading Spanish (vs. speaking/reading English or Spanish), smoking status [never (reference), former, current], work-time activity [≥ 10 minutes of continuous vigorous intensity or moderate-intensity activity at work (reference) or <10 minutes], leisure-time activity [≥ 10 minutes of continuous vigorous intensity or moderate-intensity leisure time

fitness (reference) or <10 minutes], BMI [<25.0 (reference), 25.0-29.9, 30.0-34.9, 35.0 kg/m²], hypertension (vs. no hypertension), and dyslipidemia (vs no dyslipidemia). Models were also adjusted for field center.

Previous work has shown that women are more likely to be screened for diabetes, and being uninsured is associated with having undiagnosed diabetes (19, 20). To assess these potential interactions, we first reduced the main effects model using backwards stepwise selection by assessing odds ratios, log likelihood ratios, and p-values initially >0.10 and at the final step <0.05. The effect sizes and significance of the variables in the reduced model were nearly the same as the significant variables in the full multivariable adjusted model. The main effects in the reduced model and interactions by sex and health insurance were assessed in separate models [Hispanic heritage, (sex), family history of diabetes, (health insurance status), health care in the past year, perception of limited access to health care, BMI, hypertension, and dyslipidemia], and we retained interactions at p<0.05.

For all analyses, we used SUDAAN (version 10.0.1; RTI International, Research Triangle Park, NC) to account for the complex sampling design, including unequal probabilities of selection, oversampling, and nonresponse (21).

Results

Participant Characteristics

Individuals with undiagnosed diabetes tended to be younger compared to adults with self-reported diagnosed diabetes (p=0.002) (Table 1). The distribution of Hispanic/Latino heritage differed by diabetes status with fewer adults with Puerto Rican heritage having undiagnosed diabetes compared to their counterparts with diagnosed diabetes. Persons with undiagnosed diabetes were less likely to have a family history of diabetes, and more likely to have higher household income compared to those with diagnosed diabetes (p<0.01 for both). Persons undiagnosed were more likely to have no health insurance and to have received no healthcare in the past year (p<0.001 for both). Among foreign-born individuals, those with undiagnosed diabetes were more likely to live in the U.S. for a longer period of time compared to those with diagnosed diabetes. Additionally, there were more monolingual Spanish-speakers among those with undiagnosed diabetes compared to those with diagnosed diabetes (p=0.016). Finally, persons with undiagnosed diabetes were less likely to have hypertension and more likely to have dyslipidemia compared to those with diagnosed diabetes.

Percent with Undiagnosed Diabetes by Participant Characteristics

Figure 1 shows the percentages (95% confidence intervals) of persons with diabetes who were undiagnosed. Overall, 37.0% (34.6-39.4%) were undiagnosed. The percentage of persons with undiagnosed diabetes was significantly greater for those age 18-44 years (44.9%) compared to those age 45-64 years (36.6%) or 65 years (30.6%) (p<0.008 for both). The percentage of undiagnosed was significantly lower for Dominicans (30.2%) and Puerto Ricans (26.5%) compared to those with Mexican heritage (38.7%) (p<0.03 for both). The percentage of undiagnosed was similar for men and women.

Logistic Regression

Table 2 shows the unadjusted and fully adjusted odds ratios for having undiagnosed diabetes. After multivariable adjustment for all variables listed in Table 2, factors that became non-significant included age, education, family income, nativity and years living in the U.S., and language spoken. In the adjusted model, compared to people of Mexican heritage, people of Cuban heritage had 60% higher odds and people of South American heritage had 91% higher odds of undiagnosed diabetes. In addition, individuals with higher odds of being undiagnosed included women (64%), those with no health insurance (31%), individuals who received no healthcare in the past year (compared to receiving healthcare in the U.S.) (259%), those with a BMI 25.0-29.9 kg/m² (compared to <25 kg/m²) (60%), and individuals with dyslipidemia (38%). Individuals with lower odds of being undiagnosed included those with a family history of diabetes (46%), those who self-reported a perception of limited access to healthcare (40%), and those with uncontrolled hypertension (54%).

The reduced main effects model included the same factors that were significant in the full multivariable adjusted model (Hispanic/Latino heritage, sex, family history of diabetes, health insurance, health care in the past year, perception of limited access to healthcare, BMI, hypertension, and dyslipidemia) and the associations were similar in magnitude, direction, and significance level. With further examination of interactions, we found no significant interactions by sex. There were significant interactions between health insurance and both family history of diabetes and BMI (Appendix Table 1). Among persons with a family history of diabetes, those without health insurance had a 58% higher odds of being undiagnosed compared to those with health insurance. Persons with BMI ≥ 35 kg/m² and no health insurance had 3 times higher odds of being undiagnosed compared to those with only one of these two risk factors.

Discussion

In this large population-based study of Hispanics/Latinos, we found that 37% of those with diabetes were undiagnosed. In unadjusted analysis, we found that younger adults were significantly more likely to be undiagnosed. After adjustment, several variables related to lower access to healthcare (e.g., insurance, healthcare visits) and family history of diabetes were associated with being undiagnosed. Among persons with a family history of diabetes, those with no health insurance were more likely to be undiagnosed compared to those with insurance.

The assessment of Hispanic/Latino heritage and its association with undiagnosed diabetes has important public health implications for diabetes screening and prevention. We found that individuals with South American heritage were more likely to be undiagnosed compared to those with Mexican American heritage in adjusted analysis. Previous work in the HCHS/SOL found that those with Mexican heritage had a higher prevalence of diagnosed diabetes compared to those with South American heritage; these findings suggest that those with Mexican heritage may be more likely to be diagnosed by a physician whereas those with South American heritage are not being effectively screened for diabetes (6). Additionally, previous work in NHANES, a representative sample of the U.S. population including all race/ethnicities found that Hispanics of non-Mexican-American heritage were

more likely to be undiagnosed compared to non-Hispanic whites in unadjusted analysis (15). We also found that those with Dominican or Puerto Rican heritage were less likely to be undiagnosed compared to individuals with Mexican American heritage in unadjusted analysis but these effects diminished after adjustment; this could perhaps be due to accounting for access to care. To inform physicians and patients for improved diabetes screening and care, more research is needed to determine why heritage differences in undiagnosed diabetes exist among Hispanics/Latinos in the US.

The strong and consistent association between receiving no healthcare in the past year and undiagnosed diabetes may be a result of people with diagnosed diabetes seeing healthcare providers more frequently or it may be explained by a lack of screening among people who do not frequently see a healthcare provider. We observed a similar association in NHANES (15). In addition, people without health insurance were more likely to be undiagnosed. This is consistent with a previous study along the U.S.-Mexico border that found that individuals with diabetes who did not have health insurance were more likely to be undiagnosed (22). Similarly, a previous study in HCHS/SOL found that people without health insurance were less likely to receive recommended ocular screening (23). Individuals without health insurance are less likely to see a physician regularly and without regular screenings for health problems, including diabetes, they are more likely to remain unaware of their conditions. This has important implications for public health since untreated diabetes can lead to more serious medical conditions with higher costs as individuals age. While public health programs and Federally Qualified Health Centers serving the uninsured need to focus on improving screening among those who do not have health insurance, public policy should also focus on obtaining health insurance coverage for all individuals. Finally, we found that those reporting a perception of limited access to health care were less likely to be undiagnosed; this finding may be due to participants with diagnosed diabetes more often seeking care compared to those with undiagnosed diabetes, and feeling that their health care access was inadequate for their needs.

Family history is a well-established risk factor for diabetes (24). We found that a family history of diabetes was associated with lower odds of being undiagnosed, which was also observed in NHANES (15). Screening guidelines take into account a family history of diabetes (2) and people with a family history are more likely to be screened (4). In addition, we found that health insurance modified this association such that those with a family history of diabetes and no health insurance were more likely to be undiagnosed compared to those with insurance. This suggests that health insurance plays an important role in increasing the likelihood of diabetes screening and diagnosis.

Finally, those with hypertension were less likely to be undiagnosed even after adjustment for demographic and health-related factors. This may be due to more frequent doctor visits among those with hypertension. Conversely, adults with dyslipidemia were more likely to be undiagnosed. Clinical practice guidelines recommend statin therapy for most diabetes patients, thus, we would expect that those with diagnosed diabetes are less likely to have uncontrolled lipid levels (25). While there was no association between BMI and being undiagnosed in the unadjusted model, those who were overweight were more likely to be undiagnosed after full adjustment. In this sample of Hispanic/Latinos, access to health care

and other comorbidities may be more predictive of diagnosis status than BMI. By further assessment of interactions, we found that obese adults who did not have health insurance had a significantly higher odds of being undiagnosed compared to those with only one of these two risk factors; thus the association between BMI and being undiagnosed appears to be modified by health insurance status. In addition, while older adults were less likely than younger counterparts to be undiagnosed in univariate analysis, this association became non-significant after adjustment; nevertheless, this finding has important clinical implications for diagnostic screening in younger adults. Regardless of other factors that may be associated with undiagnosed diabetes, it is important that younger adults with risk factors are screened for diabetes since they have a longer life expectancy and thus more to gain from proper diabetes management that may prevent or delay diabetes complications.

There are several study limitations for readers to consider when evaluating this study. First, the ADA recommends a repeat measurement after a single positive test based on HbA1c, FPG, or 2HPG, but HCHS/SOL participants only had these markers measured once. As a result, some participants who do not have diabetes may have been misclassified as having undiagnosed diabetes, but it is unclear how frequently this occurred (26, 27). Another possible limitation of our study is that many of the variables in our analysis were self-reported by study participants, including a physician diagnosis of diabetes, and may be subject to recall or other biases. However, self-reported diabetes has been shown to have high validity (28, 29). Although the HCHS/SOL cohort is representative of the four targeted communities, caution is urged in generalizing inferences to the larger U.S. population. Additionally, institutionalized persons were not included in the HCHS/SOL, which restricts generalizing our findings to the institutionalized population. Finally, we could not distinguish between type 1 and type 2 diabetes.

Our study has a number of important strengths, such as the use of a large population-based sample of Hispanics/Latinos in four targeted communities. The large sample size included a sufficient number of people to examine six Hispanic/Latino heritage groups and to assess interactions by sex and insurance status. The data were collected using a rigorous study protocol with extensive quality-control procedures administered by technicians trained and certified in HCHS/SOL data collection procedures.

In conclusion, we identified several variables associated with undiagnosed diabetes. Cubans, South Americans, women, the uninsured, those with no past-year healthcare use, and those with dyslipidemia were more likely to be undiagnosed. Hispanics/Latinos with a family history of diabetes, and those with hypertension were less likely to be undiagnosed. Our study, in conjunction with previous research (30), emphasizes the importance of having health insurance and regular contact with healthcare providers. In the future, these results can be used to create interventions aimed at increasing diabetes awareness and improving diabetes outcomes among specific subpopulations, such as those with Cuban or South American heritage.

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This study was approved by the Institutional Review Boards at the data coordinating center and at each field center where all subjects gave written consent.

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Appendix

Appendix Table 1.

Odds Ratios (95% Confidence Intervals) of Significant Main Effects and Interactions with Health Insurance[†] for Undiagnosed Diabetes among People with Diabetes, Hispanic Community Health Study/Study of Latinos 2008-2011

	Odds Ratio (95% CI)
No health insurance	0.77 (0.31, 1.89)
Hispanic/Latino heritage group	2.04 (1.03, 4.05)
Dominican	0.90 (0.54, 1.51)
Central American	1.66 (0.88, 3.13)
Cuban	1.41 (0.81, 2.45)
Mexican	Reference
Puerto Rican	0.89 (0.59, 1.34)
South American	2.04 (1.03, 4.05)
Women	1.45 (1.06, 1.98)
Family history of diabetes	0.70 (0.52, 0.94)
* Health insurance	0.63 (0.40, 0.98)
Healthcare in the past year	1.83 (0.93, 3.63)
Perception of limited access to healthcare	0.56 (0.33, 0.97)
BMI	
<25.0 kg/m ²	Reference
25.0-29.9 kg/m ²	1.07 (0.63, 1.80)
* No health insurance	2.33 (0.96, 5.67)
30.0-34.9 kg/m ²	1.02 (0.60, 1.73)
* No health insurance	2.34 (0.95, 5.77)
35.0 kg/m ²	1.04 (0.61, 1.78)
* No health insurance	3.16 (1.32, 7.58)
Hypertension	0.42 (0.31, 0.57)
Dyslipidemia	1.37 (1.05, 1.78)

[†] Only significant interactions are shown

References

1. American Diabetes Association. Diagnosis and classification of diabetes mellitus. *Diabetes Care*. 2010;33 Suppl 1:S62–9. [PubMed: 20042775]
2. Professional Practice Committee for the Standards of Medical Care in Diabetes-2016. *Diabetes Care*. 2016;39 Suppl 1:S1–112. [PubMed: 26696671]
3. Harris MI, Eastman RC. Early detection of undiagnosed diabetes mellitus: a US perspective. *Diabetes Metab Res Rev*. 2000;16(4):230–6. [PubMed: 10934451]
4. Kiefer MM, Silverman JB, Young BA, Nelson KM. National patterns in diabetes screening: data from the National Health and Nutrition Examination Survey (NHANES) 2005–2012. *J Gen Intern Med*. 2015;30(5):612–8. [PubMed: 25533392]
5. 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): 1021–9. [PubMed: 26348752]
6. Schneiderman N, Llabre M, Cowie CC, Barnhart J, Camethon M, Gallo LC, 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):2233–9. [PubMed: 25061138]
7. Cowie Catherine C.. Diabetes Diagnosis and Control—Missed Opportunities to Improve Health. American Diabetes Association's 78th Scientific Sessions,, 2018. Orlando, FL.
8. Harris MI, Klein R, Welborn TA, Knuiman MW. Onset of NIDDM occurs at least 4–7 yr before clinical diagnosis. *Diabetes Care*. 1992; 15(7):815–9. [PubMed: 1516497]
9. Aviles-Santa ML, Schneiderman N, Savage PJ, Kaplan RC, Teng Y, Perez CM, et al. Identifying Probable Diabetes Mellitus among Hispanics/Latinos from Four U.S. Cities: Findings from the Hispanic Community Health Study/Study of Latinos. *Endocr Pract*. 2016;22(10): 1151–60. [PubMed: 27295013]
10. Harris MI, Klein R, Cowie CC, Rowland M, Byrd-Holt DD. Is the risk of diabetic retinopathy greater in non-Hispanic blacks and Mexican Americans than in non-Hispanic whites with type 2 diabetes? A U.S. population study. *Diabetes Care*. 1998;21(8): 1230–5.
11. Lanting LC, Joung IM, Mackenbach JP, Lamberts SW, Bootsma AH. Ethnic differences in mortality, end-stage complications, and quality of care among diabetic patients: a review. *Diabetes Care*. 2005;28(9):2280–8. [PubMed: 16123507]
12. Vega WA, Rodriguez MA, Gruskin E. Health disparities in the Latino population. *Epidemiol Rev*. 2009;31:99–112. [PubMed: 19713270]
13. Casagrande SS, McEwen LN, Herman WH. Changes in Health Insurance Coverage Under the Affordable Care Act: A National Sample of U.S. Adults With Diabetes, 2009 and 20 16. *Diabetes Care*. 2018;41(5):956–62. [PubMed: 29475841]
14. Velasco-Mondragon E, Jimenez A, Palladino-Davis AG, Davis D, Escamilla-Cejudo JA. Hispanic health in the USA: a scoping review of the literature. *Public Health Rev*. 2016;37:31. [PubMed: 29450072]
15. Menke A, Casagrande S, Aviles-Santa ML, Cowie CC. Factors Associated With Being Unaware of Having Diabetes. *Diabetes Care*. 2017;40(5):e55–e6. [PubMed: 28289042]
16. Sorlie PD, Aviles-Santa LM, Wassertheil-Smoller S, Kaplan RC, Daviglus ML, Giachello AL, et al. Design and implementation of the Hispanic Community Health Study/Study of Latinos. *Ann Epidemiol*. 2010;20(8):629–41. [PubMed: 20609343]
17. Lavange LM, Kalsbeek WD, Sorlie PD, Aviles-Santa LM, Kaplan RC, Barnhart J, et al. Sample design and cohort selection in the Hispanic Community Health Study/Study of Latinos. *Ann Epidemiol*. 2010;20(8):642–9. [PubMed: 20609344]
18. Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. *Clin Chem*. 1972;18(6):499–502. [PubMed: 4337382]
19. Casagrande SS, Cowie CC, Genuth SM. Self-reported prevalence of diabetes screening in the U.S., 2005–2010. *Am J Prev Med*. 2014;47(6):780–7. [PubMed: 25241199]
20. Zhang X, Geiss LS, Cheng YJ, Beckles GL, Gregg EW, Kahn HS. The missed patient with diabetes: how access to health care affects the detection of diabetes. *Diabetes Care*. 2008;31(9): 1748–53. [PubMed: 18753665]

21. RTI International. SUDAAN® Statistical Software for Analyzing Correlated Data. RTI International; 2018.
22. Zhang X, Beckles GL, Bullard KM, Gregg EW, Albright AL, Barker L, et al. Access to health care and undiagnosed diabetes along the United States-Mexico border. *Rev Panam Salud Publica*. 2010;28(3):182–9. [PubMed: 20963265]
23. Tannenbaum SL, McClure LA, Zheng DD, Lam BL, Arheart KL, Joslin CE, et al. Ocular screening adherence across Hispanic/Latino heritage groups with diabetes: results from the Ocular SOL ancillary to the Miami site of the Hispanic Community Health Study/Study of Latinos (HCHS/SOL). *BMJ Open Diabetes Res Care*. 2016;4(1):e000236.
24. Kong AP, Luk AO, Chan JC. Detecting people at high risk of type 2 diabetes- How do we find them and who should be treated? *Best Pract Res Clin Endocrinol Metab*. 2016;30(3):345–55. [PubMed: 27432070]
25. Standards of medical care in diabetes--2011. *Diabetes Care*. 2011;34 Suppl 1:S11–61. [PubMed: 21193625]
26. Christophi CA, Resnick HE, Ratner RE, Temprowsa M, Fowler S, Knowler WC, et al. Confirming glycemic status in the Diabetes Prevention Program: implications for diagnosing diabetes in high risk adults. *J Diabetes Complications*. 2013;27(2):150–7. [PubMed: 23140912]
27. Mooy JM, Grootenhuys PA, de Vries H, Kostense PJ, Popp-Snijders C, Bouter LM, et al. Intraindividual variation of glucose, specific insulin and proinsulin concentrations measured by two oral glucose tolerance tests in a general Caucasian population: the Hoorn Study. *Diabetologia*. 1996;39(3):298–305. [PubMed: 8721775]
28. Jackson JM, DeFor TA, Crain AL, Kerby TJ, Strayer LS, Lewis CE, et al. Validity of diabetes self-reports in the Women's Health Initiative. *Menopause*. 2014;21(8):861–8. [PubMed: 24496083]
29. Schneider AL, Pankow JS, Heiss G, Selvin E. Validity and reliability of self-reported diabetes in the Atherosclerosis Risk in Communities Study. *Am J Epidemiol*. 2012;176(8):738–43. [PubMed: 23013620]
30. Starfield B, Shi L, Macinko J. Contribution of primary care to health systems and health. *Milbank Q*. 2005;83(3):457–502. [PubMed: 16202000]

Highlights

- 37% of Hispanic/Latino adults with diabetes were undiagnosed
- Individuals of Cuban or South American heritage were more likely to be undiagnosed
- Those without health insurance or recent healthcare were more likely to be undiagnosed
- Those with family history of diabetes were less likely to be undiagnosed

Figure 1.
The Weighted Percentage of Adults with Diabetes who were Undiagnosed Overall and by Age, Hispanic Heritage, and Sex, Hispanic Community Health Study/Study of Latinos 2008-2011

Table 1.

Study Characteristics (standard error) of Adults with Diabetes, Hispanic Community Health Study/Study of Latinos 2008-2011

	Self-Reported Diagnosed Diabetes	Undiagnosed Diabetes	p-value
N	2,151	1,233	
Age in years			0.002
18-44	20.2 (1.52)	28.0 (1.99)	
45-64	52.2 (1.47)	51.2 (1.98)	
65-76	27.7 (1.51)	20.8 (1.86)	
Hispanic/Latino heritage group			<0.001
Dominican	10.8 (1.18)	8.2 (1.09)	
Central American	6.2 (0.66)	7.7 (0.94)	
Cuban	19.9 (2.22)	24.6 (2.53)	
Mexican	34.9 (2.08)	38.8 (2.61)	
Puerto Rican	22.7 (1.43)	14.4 (1.47)	
South American	2.6 (0.40)	4.2 (0.67)	
Women	53.0 (1.56)	57.1 (1.99)	0.100
Family history of diabetes	64.9 (1.68)	53.6 (2.17)	<0.001
Education			0.075
< high school education	32.7 (1.72)	30.2 (2.04)	
High school education	20.6 (1.54)	26.2 (1.97)	
> high school education	46.7 (1.57)	43.6 (2.12)	
Household Income			0.009
<\$10,000	21.5 (1.40)	16.8 (1.37)	
\$10,000-19,999	35.2 (1.61)	33.2 (1.95)	
\$20,000-39,999	28.1 (1.55)	35.0 (1.97)	
\$40,000-74,999	10.7 (1.14)	12.5 (1.73)	
\$75,000	4.4 (0.79)	2.6 (0.62)	
No health insurance	32.4 (1.44)	50.3 (2.26)	<0.001
Healthcare in the past year			<0.001
In the United States	85.9 (1.22)	67.7 (1.91)	
In another country	6.5 (0.94)	8.7 (1.18)	
No healthcare	7.6 (0.81)	23.6 (1.78)	
Perception of limited access to healthcare	15.5 (1.03)	14.9 (1.38)	0.741
Nativity and Years living in US			0.002
Foreign- born (FB) 1-2 years	13.1 (1.17)	9.5 (1.19)	
FB 3-5 years	4.0 (0.56)	7.0 (1.31)	
FB 6-10 years	5.2 (0.74)	7.5 (1.23)	
FB 11-15 years	9.4 (1.26)	12.8 (1.47)	
FB >15 years	9.0 (0.91)	10.4 (1.11)	

	Self-Reported Diagnosed Diabetes	Undiagnosed Diabetes	p-value
Born in the 50 U.S. states or DC	59.2 (1.87)	52.8 (2.30)	
Spanish language spoken only	50.0 (1.74)	56.2 (2.04)	0.016
Smoking status			0.322
Never	54.8 (1.46)	58.3 (1.98)	
Former	26.0 (1.33)	24.2 (1.62)	
Current	19.2 (1.38)	17.4 (1.62)	
Low work time activity levels	72.5 (1.47)	70.7 (1.81)	0.439
Low leisure time activity levels	71.3 (1.60)	73.2 (1.87)	0.438
BMI			0.708
<25.0 kg/m ²	10.5 (1.01)	9.2 (1.14)	
25.0-29.9 kg/m ²	33.8 (1.47)	33.5 (1.93)	
30.0-34.9 kg/m ²	31.0 (1.47)	30.8 (1.81)	
35.0 kg/m ²	24.8 (1.35)	26.6 (1.74)	
Hypertension	64.5 (1.63)	45.9 (1.90)	<0.001
Dyslipidemia	45.9 (1.78)	55.0 (1.97)	0.001

Percentages and standard errors are weighted estimates.

Table 2.

Odds Ratios (95% Confidence Intervals) of Undiagnosed Diabetes among People with Diabetes, Hispanic Community Health Study/Study of Latinos 2008-2011

	Unadjusted	Adjusted [†]
Age in years		
18-44	Reference	Reference
45-64	0.71 (0.55-0.91)	0.87 (0.64-1.17)
65-74	0.54 (0.38-0.76)	0.79 (0.52-1.20)
Hispanic/Latino heritage group		
Dominican	0.69 (0.49-0.96)	1.13 (0.77-1.66)
Central American	1.13 (0.79-1.60)	1.05 (0.66-1.69)
Cuban	1.11 (0.82-1.49)	1.60 (1.02-2.50)
Mexican	Reference	Reference
Puerto Rican	0.57 (0.44-0.74)	1.08 (0.79-1.47)
South American	1.45 (0.93-2.27)	1.91 (1.16-3.14)
Women	1.18 (0.97-1.44)	1.64 (1.26-2.13)
Family history of diabetes	0.63 (0.51-0.77)	0.54 (0.43-0.68)
Education		
< high school education	0.99 (0.78-1.25)	0.90 (0.66-1.23)
High school education	1.36 (1.03-1.78)	1.27 (0.95-1.71)
> high school education	Reference	Reference
Household Income		
<\$10,000	1.30 (0.70-2.43)	0.99 (0.51-1.95)
\$10,000-19,999	1.57 (0.85-2.91)	1.18 (0.62-2.24)
\$20,000-39,999	2.08 (1.12-3.85)	1.59 (0.85-2.96)
\$40,000-74,999	1.95 (1.00-3.81)	1.62 (0.83-3.15)
\$75,000	Reference	Reference
No health insurance	2.11 (1.71-2.61)	1.31 (1.00-1.71)
Healthcare in the past year		
In the United States	Reference	Reference
In another country	1.70 (1.15-2.50)	1.39 (0.85-2.25)
No healthcare	3.92 (2.94-5.23)	3.59 (2.49-5.16)
Perception of limited access to healthcare	0.96 (0.74-1.24)	0.60 (0.44-0.81)
Nativity and Years living in US		
Foreign- born (FB) 1-2 years	2.43 (1.45-4.10)	1.25 (0.60-2.61)
FB 3-5 years	1.98 (1.17-3.34)	1.09 (0.53-2.24)
FB 6-10 years	1.88 (1.19-2.97)	1.00 (0.58-1.73)
FB 11-15 years	1.59 (1.06-2.38)	0.92 (0.56-1.49)
FB >15 years	1.23 (0.88-1.74)	1.22 (0.81-1.84)

	Unadjusted	Adjusted [†]
Born in the 50 U.S. states or DC	Reference	Reference
Spanish language spoken only	1.28 (1.04-1.57)	1.10 (0.84-1.45)
Smoking status		
Never	Reference	Reference
Former	0.88 (0.70-1.09)	0.95 (0.73-1.23)
Current	0.85 (0.64-1.13)	0.80 (0.57-1.13)
Low work time activity levels	0.92 (0.74-1.14)	0.91 (0.70-1.19)
Low leisure time activity levels	1.10 (0.87-1.39)	1.10 (0.85-1.44)
BMI		
<25.0 kg/m ²	Reference	Reference
25.0-29.9 kg/m ²	1.13 (0.78-1.64)	1.60 (1.02-2.50)
30.0-34.9 kg/m ²	1.13 (0.78-1.66)	1.47 (0.92-2.33)
35.0 kg/m ²	1.23 (0.86-1.76)	1.50 (0.94-2.38)
Hypertension	0.47 (0.38-0.57)	0.46 (0.36-0.58)
Dyslipidemia	1.44 (1.18-1.75)	1.38 (1.10-1.74)

[†] Adjusted for all other variables listed in the table Estimates are weighted