Disparities in undiagnosed diabetes among United States–Mexico border populations

Pamela Stoddard,[1] *Guozhong He,*[2,3] *Maya Vijayaraghavan,*[4] *and Dean Schillinger*[2,3,4,5]

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ABSTRACT

Objective. *To compare the prevalence of undiagnosed diabetes among populations with diabetes living on the United States (U.S.)–Mexico border, examine explanations for differences between groups, and investigate differences in metabolic outcomes by diagnosis status.*

Methods. *Data come from the U.S.–Mexico Border Diabetes Prevention and Control Project survey (2001–2002), which used a stratified, multistage design. The sample included 603 adults (18 years or older) with diabetes. Undiagnosed diabetes was defined as a fasting plasma glucose (FPG) value of ≥ 126 mg/dL and no report of diagnosis. Logistic regression was used to compare the odds of being undiagnosed among border populations with diabetes. Metabolic outcomes included FPG, glycosylated hemoglobin, and mean arterial blood pressure.*

Results. *One in four adults with diabetes (25.9%) living on the U.S.–Mexico border was undiagnosed. Mexicans (43.8%) and Mexican immigrants (39.0%) with diabetes were significantly more likely to be undiagnosed than were U.S.-born Hispanics (15.0%; $P < 0.05$ for either comparison) or non-Hispanic whites (6.6%; $P < 0.001$ for either comparison). Mexicans were more likely to be undiagnosed than were all U.S. adults (14.7%; $P < 0.001$) with diabetes. Significant differences in the likelihood of being undiagnosed remained between all groups with diabetes after adjustment for sociodemographic and healthcare-related covariates, with the exception of that between Mexicans and U.S.-born Hispanics. Worse metabolic control and potentially greater benefits of diagnosis for control were observed for Mexicans in particular compared with U.S. groups with undiagnosed diabetes.*

Conclusions. *Efforts to improve diabetes diagnosis should concentrate on Mexican and Mexican immigrant populations on the U.S.–Mexico border.*

Key words Diabetes mellitus, type 2; diagnosis; healthcare disparities; border health; Hispanic Americans; United States; Mexico.

[1] Philip R. Lee Institute for Health Policy Studies, University of California, San Francisco, San Francisco, California, United States of America.
[2] Institute on Health and Aging, University of California, San Francisco, San Francisco, California, United States of America.
[3] California Diabetes Program, California Department of Public Health, Sacramento, California, United States of America. Send correspondence to Guozhong He, ghe@dhs.ca.gov
[4] Department of General Internal Medicine, University of California, San Francisco, San Francisco, California, United States of America.
[5] Center for Vulnerable Populations and San Francisco General Hospital, University of California, San Francisco, San Francisco, California, United States of America.

As the global burden of type 2 diabetes grows, undiagnosed diabetes will increasingly represent a public health concern (1–3). In the years before diagnosis, risk factors for microvascular and macrovascular complications are elevated (4). If this period is lengthy complications may develop and progress (4). At diagnosis, approximately one in five individuals with type 2 diabetes already has retinopathy, neuropathy, or nephropathy (5). Moreover, cardiovascular disease, which is the cause of death in three-fourths of adults with diabetes, begins to develop early in the course of diabetes (6, 7). Earlier detection of diabetes may thus reduce or delay the development of complications (8, 9), prevent or decrease diabetes-related mortality, and lower healthcare costs (1, 2).

This study examined differences in the prevalence of undiagnosed diabetes among populations with diabetes living on the United States of America (U.S.)–

Mexico border, along with explanations for variation between groups. The investigation used data from the U.S.–Mexico Border Diabetes Prevention and Control Project survey collected in 2001–2002. The goal of the project was to reduce the impact of diabetes on residents living along the U.S. and Mexico borders, with a view of the border region as a single epidemiologic unit (10). Research based on mortality data before initiation of the project suggests that regional residents were at higher risk of diabetes-related mortality than the general population in the two countries (10). Preliminary estimates from the project suggest that diabetes prevalence was higher in the border region than in Mexico or the United States as a whole at the time of the survey—16.1% on the U.S. border, compared with 9.3% of the U.S. population, and 15.1% on the Mexico border, compared with 7.5% of the Mexican population (10–12). By extension, the number of cases of undiagnosed diabetes in the region is likely to be substantial, suggesting an urgent need for research to guide intervention, particularly in identifying border populations at highest risk of being undiagnosed. With this goal, the current study compared prevalence of undiagnosed diabetes in the Mexico and U.S. border populations with diabetes as well as in three U.S. border subgroups with diabetes—U.S.-born Hispanics, Mexican immigrants, and non-Hispanic whites.

In addition to a pressing need for research to guide intervention, the region offers unique opportunities for studying the impact of access to healthcare on undiagnosed diabetes in different contexts, given differences in such access in the U.S. and Mexican healthcare systems. Lack of access to health insurance at the time of the survey was higher in Mexico than in the United States (approximately 50% and approximately 15%, respectively) (13–15). Prevalence of uninsurance was likely to vary within the U.S. border population as well. High rates of uninsurance have been documented in the United States among Hispanics, who make up the majority of the population along the U.S. border (15–21). Within the Hispanic population in the United States, especially high rates of uninsurance have been found among Hispanic immigrants (15–21). Lack of insurance coverage and lack of a usual place of care have been found to be associated with undiagnosed diabetes and use of diabetes screening services in the United States and Mexico (22, 23). Disparities in diagnosis between Mexico and U.S. border populations with diabetes may be compounded by differences in healthcare system capacity around diabetes screening. The Mexican health system is grappling with communicable diseases and reproductive health needs common to a middle-income country, while attempting to address the rising prevalence of noncommunicable diseases like diabetes (24). This may affect access to and quality of diabetes screening services. A better understanding of the extent of variation in diagnosis between Mexico and U.S. border populations with diabetes, and the extent to which healthcare access contributes to this variation, may guide strategies for improving diagnosis rates. It may also hold lessons for other regions with disparities in access to quality preventive care services.

Although access to high-quality preventive care services is an essential condition for diabetes diagnosis, other characteristics are also likely to contribute to differences in diagnosis between regional subgroups. Prior research has found undiagnosed diabetes and lower use of diabetes screening services to be associated with younger age, being male, having less education and lower income, and having a higher body mass index, all of which vary within border populations (22, 23, 25–27). Access to health information about diabetes may also influence diagnosis and is likely to vary across regional subgroups. An understanding of the extent to which these characteristics explain variation in risk for undiagnosed diabetes among regional subgroups may inform efforts to improve detection and offer insights for other sociodemographically diverse regions.

The central hypothesis was that the prevalence of undiagnosed diabetes would vary among border populations with diabetes and that disparities would partially be explained by differences in access to healthcare, access to health information about diabetes, and sociodemographic characteristics. More specifically, it was anticipated that Mexicans with diabetes residing on the Mexico border and Mexican immigrants with diabetes residing on the U.S. border would be more likely to be undiagnosed than U.S.-born Hispanics or non-Hispanic whites with diabetes, given less access to quality healthcare and screening services, less education, and younger age on average. Mexican immigrants were also more likely to be male than were other regional populations due to higher immigration of men than women from Mexico to the United States, which may have contributed to a higher prevalence of being undiagnosed. Although nationwide studies have suggested that access to health insurance is relatively low among U.S. Hispanics in general, access was likely to be high among Hispanics with diabetes who were born in the United States, which may have contributed to a greater likelihood of diagnosis for this group than for Mexican immigrants with diabetes (15, 28). Given this access, U.S.-born Hispanics with diabetes were expected to have a similar likelihood of being undiagnosed as non-Hispanic whites with diabetes.

This study had two main objectives: to compare the prevalence of undiagnosed diabetes among adult populations with diabetes living in the border region and to examine explanations for differences between groups as a step to further guide intervention. In addition, average values of metabolic outcomes were assessed by diagnosis status in regional populations with diabetes in order to compare the potential benefit of diagnosis within and between border groups.

MATERIALS AND METHODS

Data source

The U.S.–Mexico Border Diabetes Prevention and Control Project survey was representative of the noninstitutionalized adult population living in counties contiguous to the U.S.–Mexico border in 2001–2002. Data were collected in four U.S. border states (California, Arizona, New Mexico, and Texas) and in six Mexico border states (Baja California, Sonora, Chihuahua, Coahuila, Nuevo Leon, and Tamaulipas). The survey used a stratified, multistage probability design. One adult aged 18 years or older was randomly sampled within selected households. The survey was conducted in 44 border communities (28 in Mexico and 16 in the United States). Hispanic adults on the U.S. border were oversampled (29). The response rate was 93.5%.

Face-to-face interviews were conducted with each sampled adult. In the United States, participants were interviewed in the language of preference (English or Spanish). All responding adults were asked to participate in a health as-

sessment, which collected anthropometric and blood pressure measurements as well as a fasting blood sample (29).

Sample

A total of 4 027 adults completed the survey. Of them, 3 536 had a valid measure of fasting plasma glucose (FPG), which, along with self-reports of diabetes diagnosis, was used to determine diagnosis status. The analytic sample included all respondents with diabetes (whether diagnosed or undiagnosed) with no missing data on any study variables, yielding a total of 603 individuals. Diabetes was defined as having a FPG of ≥ 126 mg/dL or a FPG of < 126 mg/dL and a self-reported diabetes diagnosis from a healthcare professional, excluding women who were diagnosed with diabetes only during pregnancy.

Variable definition

The primary outcome was undiagnosed diabetes, defined as having a FPG of ≥ 126 mg/dL but never having been diagnosed with diabetes by a healthcare professional. Women with diabetes, based on FPG values, who had been diagnosed with diabetes by a healthcare professional only during pregnancy were defined as undiagnosed.

The main predictor of interest was regional subgroup, defined based on self-reports of race and ethnicity (Hispanic versus non-Hispanic), birthplace (in the United States or in Mexico), and border region of residence (U.S. or Mexico border). All adults with diabetes residing on the Mexico border were included in one subgroup, hereafter referred to as Mexicans. All adults with diabetes residing on the U.S. border, hereafter referred to as U.S. adults, were included as a second subgroup. The group included individuals with diabetes from all racial and ethnic backgrounds, including Hispanics and non-Hispanics who identified as white, African-American, Asian or Pacific Islander, American Indian, Alaskan Native, or another racial or ethnic group. The U.S. adult subgroup includes individuals with diabetes from these racial and ethnic groups born both in and outside the United States. Within the U.S. border population with diabetes, three subgroups were defined: U.S.-born Hispanics, Mexican immigrants (individuals born in Mexico but currently residing on the U.S. border), and non-Hispanic whites. The survey did not query U.S.-born Hispanic respondents about country of origin; however, the vast majority of U.S.-born Hispanics living on the southwestern U.S. border are likely to be of Mexican descent (30). For the purposes of representativeness, all other U.S. adults with diabetes were included in the category of all U.S. adults for descriptive and regression analyses; however, separate results for this group are not presented (available upon request).

Other explanatory variables include age (18 to 44 years, 45 to 64 years, and 65 years or older), gender, education (none or primary school, middle school, high school, or more than high school), and obesity (defined as a body mass index ≥ 30.0) as well as several binary measures of healthcare access and utilization based on self-reports. The first of these measures was access to health insurance. Insured individuals were those who indicated that they had primary medical coverage of any kind through public, private, or other sources of insurance in their country of residence. Uninsured individuals were those who lacked primary medical coverage from any source. A variable for usual place of care was based on responses to the question, "Is there a particular clinic, health center, or doctor that you usually go to when you are sick or need routine healthcare?" Participants who responded in the affirmative and indicated that they usually went to a private doctor's office, public clinic, or military health facility for healthcare or received care via medical facilities associated with Mexico's insurance programs were defined as having a usual place of care. Those who responded negatively or indicated that their usual place of care was an emergency department or pharmacy were classified as not having a usual place of care. A variable was also included for whether an individual reported having visited a doctor or other healthcare worker in the 12 months preceding the survey. Finally, as a measure of exposure to health information about diabetes, a binary variable was included indicating whether the participant had heard, seen, or read anything about how diabetes could be avoided or prevented in the 12 months before the survey. Metabolic measures, collected via the health assessment, included FPG, glycosylated hemoglobin (HbA1c), and mean arterial blood pressure. Mean arterial blood pressure was based on the average of three measures of systolic and diastolic blood pressure and was calculated as $1/3 \times$ systolic + $2/3 \times$ diastolic.

Analysis

Descriptive statistics are presented for sociodemographic characteristics, healthcare access and utilization, and exposure to health information about diabetes among adults with diabetes in each border population. The prevalence of undiagnosed diabetes among regional subgroups with diabetes was also estimated. Chi-square tests were used to test for differences among groups in these characteristics. Mean values of metabolic outcomes are also provided for each group by diagnosis status. Differences in these outcomes within and between groups were tested via least-squares regression. All estimates were weighted using weights provided by the U.S.–Mexico Border Diabetes Prevention and Control Project (29).

A series of logistic regression models were then estimated for undiagnosed diabetes. In Model 1, unadjusted odds ratios (ORs) were estimated for all U.S. adults with diabetes and for each U.S. subgroup with diabetes relative to Mexicans (the reference group). Subsequent models controlled for each individual explanatory variable followed by the full model (all variables). These odds were also calculated for the three U.S. subgroups relative to one another. A sensitivity analysis of the odds of being undiagnosed among Mexican immigrants versus Mexican adults with diabetes was conducted, adjusting for having a usual place of care on the opposite side of the border (i.e., in Mexico for Mexican immigrants and in the United States for Mexicans). This analysis was intended to isolate differences in being undiagnosed between the two groups that might be due to a lack of healthcare access and utilization in the country of residence, given that it is not uncommon for Mexican immigrants to seek healthcare in Mexico rather than solely in the United States. (31). All analyses were conducted with SAS (version 9.13) and SUDAAN to adjust for the complex sampling scheme in the survey.

RESULTS

With respect to demographic characteristics among adults with diabetes (Table 1), the Mexican border population had a younger age distribution than the U.S. border population as a whole as well as all U.S. border subgroups, with half under the age of 45 years. Within the U.S. border population with diabetes, U.S.-born Hispanics had the youngest age distribution, with more than one-third under the age of 45 years. Mexican immigrants with diabetes were disproportionately male (64.9%), whereas among other U.S. subgroups adults with diabetes were more likely to be women. Mexicans with diabetes were equally likely to be men or women. Mexicans and Mexican immigrants with diabetes had substantially lower educational attainment than other border populations. In all populations, large proportions of adults with diabetes were obese—more so among U.S.-born Hispanics and Mexican immigrants than in other groups. Results from tests of statistical significance of the differences in these characteristics between groups, as well as those for healthcare-related characteristics, can be found in Table 1.

Most adults with diabetes in the region had health insurance, had a usual place of care, and had visited a doctor in the past 12 months. The exception was Mexican immigrants with diabetes, among whom fewer than half were insured. However, more than three-fourths of this group reported a usual place of care and a similar proportion had seen a doctor in the past 12 months. Mexicans and non-Hispanic whites with diabetes had the least exposure to health information about diabetes prevention (56.3% and 52.3%, respectively) of border subgroups, and U.S.-born Hispanics had the most exposure (80.5%).

Diagnosis status and metabolic outcomes

In the border region as a whole, approximately one in four adults with diabetes (25.9%) was undiagnosed (lower panel, Table 1). The likelihood of being undiagnosed was three times as high among Mexicans as for all U.S. adults

TABLE 1. Sociodemographic, healthcare, and health-related characteristics of adults with diabetes in U.S.–Mexico border populations, U.S.–Mexico Diabetes Prevention and Control Project Survey, 2001–2002[a] (*n* = 603)

Characteristic	U.S. border population					
	Border (all)[b] (*n* = 603)	Mexican[c] (*n* = 300)	U.S. (all)[d] (*n* = 303)	U.S.-born Hispanic (*n* = 90)	Mexican immigrant (*n* = 157)	Non-Hispanic white (*n* = 44)
Sociodemographics						
Age (%)						
18–44 years	33.3	50.6	22.4[e]	39.2	16.0[c]	18.4[e,f]
45–64 years	39.7	36.5	41.6	38.6	62.5	24.8
≥ 65 years	27.0	12.8	35.9	22.1	21.4	56.8
Men (%)	47.0	50.4	44.9	40.2	64.9	40.7
Education level (%)						
None or primary school	30.1	57.5	13.0[f]	12.9[f]	44.8[g,h]	1.7[e,f]
Middle school	18.5	20.8	17.1	16.0	25.1	17.6
High school	26.7	6.1	39.5	52.7	8.3	33.6
More than high school	24.7	15.6	30.4	18.4	21.8	47.1
Body mass index (%)						
Normal weight	15.2	20.2	12.1	2.8[f]	11.4	19.3
Overweight	30.2	33.6	28.1	26.3	27.0	36.1
Obese	54.6	46.2	59.8	70.9	61.6	44.7
Healthcare and health information (%)						
Has health insurance	80.0	76.4	82.3	85.0	46.0[f,g]	96.0[e,f]
Has usual place of care	89.8	90.8	89.3	93.2	79.9	89.2
Had doctor's visit in past 12 months	83.0	71.8	90.0[f]	93.6[f]	75.1	92.9[f]
Exposed to health information about diabetes	61.6	56.3	65.0	80.5[f]	60.4	52.3
Health outcome (%)						
Undiagnosed adults with diabetes	25.9	43.8	14.7[f]	15.0[f]	39.0[g]	6.6[e,f]
Fasting plasma glucose (mg/dL, mean ± standard deviation)						
Undiagnosed	188.7 ± 7.1	193.5 ± 8.2	179.9 ± 14.0	170.9 ± 12.5	193.5 ± 21.5	150.3 ± 8.1[f]
Diagnosed	138.8 ± 5.9	149.3 ± 8.6[h]	134.5 ± 7.3[h]	140.7 ± 14.4	154.4 ± 6.9	130.3 ± 11.9
Hemoglobin A1c (%, mean ± standard deviation)						
Undiagnosed	8.0 ± 0.3	8.6 ± 0.3	7.0 ± 0.5[e]	6.7 ± 0.5[e]	7.7 ± 0.6	5.6 ± 0.3[e,f]
Diagnosed	6.9 ± 0.2	7.2 ± 0.3[e]	6.7 ± 0.2	7.1 ± 0.3	7.7 ± 0.3	6.4 ± 0.3
Arterial blood pressure (mm Hg, mean ± standard deviation)						
Undiagnosed	93.4 ± 1.2	91.9 ± 1.7	96.3 ± 1.2[f]	96.0 ± 1.7[f]	97.1 ± 1.8	94.3 ± 1.7[e,f]
Diagnosed	98.3 ± 1.5	98.8 ± 1.6[f]	98.1 ± 2.0	98.9 ± 2.6	99.8 ± 1.5	95.6 ± 3.5

[a] Estimates are weighted using weights provided by the U.S.–Mexico Border Diabetes Prevention and Control Project. Percentages may not add to 100% due to rounding.
[b] Border (all) includes all adults with diabetes living on the U.S.–Mexico border.
[c] Mexican includes adults with diabetes living on the Mexico border.
[d] U.S. (all) includes all adults with diabetes living on the U.S. border from all racial and ethnic backgrounds, including Hispanics and non-Hispanics who identified as white, African-Americans, Asians and Pacific Islanders, American Indians, and Alaskan Natives. The category also includes U.S.-born Hispanics and Mexican immigrants (born in Mexico but living on the U.S. border).
[e] Set of categories or mean significantly different from Mexican immigrants at $P < 0.05$.
[f] Set of categories or mean significantly different from Mexicans at $P < 0.05$.
[g] Set of categories or mean significantly different from U.S.-born Hispanics at $P < 0.05$.
[h] Significantly different from undiagnosed at $P < 0.05$.

with diabetes (43.8% versus 14.7%, $P < 0.001$). Mexican immigrants with diabetes were less likely to be undiagnosed than were Mexicans (39.0% versus 43.8%) but the difference was not statistically significant. As hypothesized, Mexicans and Mexican immigrants with diabetes were significantly less likely to be diagnosed than were U.S.-born Hispanics (14.7% undiagnosed, $P < 0.05$ for comparisons with either group) or non-Hispanic whites with diabetes (6.6% undiagnosed, $P < 0.001$ for comparisons with either group). There was no significant difference in the likelihood of diagnosis for U.S.-born Hispanics versus non-Hispanic whites with diabetes.

In terms of metabolic outcomes among adults with diabetes who were undiagnosed, mean FPG (188.7 mg/dL) and HbA1c (8.0%) were high among all border adults, indicating a risk for accelerated diabetes complications in the region as a whole. Mean FPG was higher among undiagnosed Mexicans versus all undiagnosed U.S. adults (193.5 mg/dL versus 179.9 mg/dL) as well as U.S.-born Hispanics (170.9 mg/dL) and non-Hispanic whites (150.3 mg/dL), although differences were significant only for the latter group ($P < 0.001$). Undiagnosed Mexican adults, however, had a clinically and statistically significantly higher HbA1c on average than did undiagnosed U.S. adults (8.6% versus 7.0%, $P = 0.008$), undiagnosed U.S.-born Hispanics (6.7%, $P = 0.003$), and undiagnosed non-Hispanic whites (5.6%, $P < 0.001$). There were no significant differences in mean FPG or HbA1c for undiagnosed Mexicans versus undiagnosed Mexican immigrants. Mean FPG was marginally higher among undiagnosed Mexican immigrants (193.5 mg/dL) than among undiagnosed non-Hispanic whites ($P = 0.06$) and mean HbA1c was significantly higher among the former than the latter (7.7% versus 5.6%, $P = 0.002$). There were no significant differences in mean FPG or HbA1c between undiagnosed U.S.-born Hispanics and undiagnosed Mexican immigrants.

A comparison of glucose measures within regional subgroups with diabetes by diagnosis status revealed that mean FPG was higher for undiagnosed versus diagnosed individuals in each population; differences were statistically significant for Mexicans and all U.S. adults at $P < 0.05$ and for Mexican immigrants at $P < 0.10$. Mean HbA1c was higher among undiagnosed than among diagnosed Mexicans and all U.S. adults with diabetes, although differences were statistically significant only for Mexicans ($P < 0.001$). Mexican immigrants with diabetes showed no difference in mean HbA1c by diagnosis status (7.7%). Notably, HbA1c was lower for undiagnosed versus diagnosed U.S.-born Hispanics and non-Hispanic whites with diabetes, although differences were not statistically significant.

The magnitude of the difference in mean FPG by diagnosis status in the Mexican versus U.S. population with diabetes was similar (a difference of 44.0 mg/dL for Mexicans versus 45.0 mg/dL for U.S. adults, P for comparison = 0.96). Although the gap by diagnosis was larger for Mexicans than for each U.S. subgroup with diabetes, differences were not statistically significant. However, the size of the difference in mean HbA1c by diagnosis status among Mexicans with diabetes was significantly larger than that of U.S. adults (1.4% versus 0.3%, $P = 0.008$), U.S.-born Hispanics (0.4%, $P = 0.003$), and non-Hispanic whites (0.8%, $P < 0.001$) with diabetes. Among U.S. subgroups with diabetes, the largest improvement in mean FPG by diagnosis status was evident among Mexican immigrants (39.1 mg/dL versus 30.2 mg/dL for U.S.-born Hispanics and 20.0 mg/dL for non-Hispanic whites), but differences were not significant.

There was no evidence of lower mean arterial blood pressure on average among diagnosed versus undiagnosed adults with diabetes in any regional subgroup. In fact, undiagnosed adults in each border population had a slightly lower mean arterial blood pressure on average than did diagnosed adults; differences were significant only for Mexicans ($P = 0.003$). Undiagnosed Mexicans had significantly lower mean arterial blood pressure on average than did undiagnosed U.S. adults (91.9 mm Hg versus 96.3 mm Hg, $P = 0.04$) and undiagnosed Mexican immigrants (97.1 mm Hg, $P = 0.04$) as well as marginally lower levels than undiagnosed U.S.-born Hispanics (96.0 mm Hg, $P = 0.09$). Levels among undiagnosed Mexicans were not significantly different from those of undiagnosed non-Hispanic whites (94.3 mm Hg, $P = 0.32$). The magnitude of the difference in average mean arterial blood pressure by diagnosis status did not vary significantly between subgroups.

Multivariate results

The unadjusted model in Table 2 (Model 1, first column) confirms that U.S. adults with diabetes were significantly less likely to be undiagnosed than were

TABLE 2. Odds ratios of undiagnosed diabetes among adults with diabetes in U.S.–Mexico border populations, U.S.–Mexico Border Diabetes Prevention and Control Project Survey, 2001–2002 (n = 603)

Model[a]	U.S. (all)[b]		U.S.-born Hispanic		Mexican immigrant		Non-Hispanic white	
	OR[c]	95% CI[d]	OR	95% CI	OR	95% CI	OR	95% CI
Model 1: unadjusted	0.22	0.12–0.41	0.23	0.08–0.63	0.82	0.41–1.64	0.09	0.03–0.31
Model 1 + age	0.27	0.14–0.51	0.23	0.06–0.93	1.33	0.66–2.66	0.12	0.04–0.38
Model 1 + gender	0.22	0.12–0.41	0.23	0.09–0.63	0.79	0.40–1.53	0.09	0.03–0.31
Model 1 + education	0.19	0.10–0.37	0.18	0.06–0.56	0.80	0.40–1.59	0.07	0.02–0.24
Model 1 + obesity	0.22	0.12–0.42	0.23	0.08–0.65	0.84	0.42–1.68	0.09	0.03–0.31
Model 1 + healthcare access/utilization	0.24	0.13–0.46	0.27	0.10–0.73	0.82	0.38–1.79	0.10	0.03–0.36
Model 1 + health information	0.24	0.13–0.43	0.26	0.10–0.69	0.84	0.42–1.69	0.09	0.03–0.32
All variables	0.28	0.14–0.57	0.28	0.07–1.07	1.33	0.62–2.84	0.10	0.03–0.35

[a] Reference value: Mexicans.
[b] U.S. (all) includes all adults with diabetes living on the U.S. border, including U.S.-born Hispanics, Mexican immigrants, non-Hispanic whites, and individuals from other racial, ethnic, and immigrant groups.
[c] OR: odds ratio.
[d] CI: confidence interval.

Mexican adults with diabetes (OR 0.22, 95% confidence interval [CI] 0.12–0.41). U.S.-born Hispanics (OR 0.23, 95% CI 0.08–0.63) and non-Hispanic whites (OR 0.09, 95% CI 0.03–0.31) with diabetes also had significantly lower odds of being undiagnosed than did Mexicans with diabetes. Although Mexican immigrants with diabetes had lower odds of being undiagnosed than Mexican adults with diabetes, the difference was not statistically significant (OR 0.82, 95% CI 0.41–1.64). Comparing nonreference groups (data not shown), non-Hispanic whites with diabetes were significantly less likely to be undiagnosed than Mexican immigrants with diabetes (OR 0.11, 95% CI 0.03–0.40), as were U.S.-born Hispanics (OR 0.28, 95% CI 0.09–4.62). There were no differences in the odds of being undiagnosed for U.S.-born Hispanic adults with diabetes relative to non-Hispanic whites with diabetes.

Turning to mediation of the difference in the odds of being undiagnosed between all U.S. adults with diabetes versus all Mexican adults with diabetes (column 1, subsequent models in Table 2), age had the most substantial explanatory effect (changing the OR from 0.22 to 0.27, 95% CI 0.14–0.51). Subsequent models suggest that gender, obesity, healthcare access and utilization, and exposure to health information did little to explain the differences between the two groups. Controlling for education (separately), U.S. adults with diabetes were even less likely to be undiagnosed than Mexican adults with diabetes than in the unadjusted model. Although the difference between the two groups decreased after adjusting for all explanatory variables (OR 0.28, 95% CI 0.14–0.57), the difference remained statistically significant. Similar patterns were evident for differences in the odds of being undiagnosed for non-Hispanic whites versus Mexicans with diabetes.

The lower odds of being undiagnosed among U.S.-born Hispanic versus Mexican adults with diabetes also changed little with adjustment (considered individually) for age, gender, and obesity. Healthcare and health information variables explained a small portion of the difference in the odds of being undiagnosed between the two groups. Education again increased the difference between the two groups. No significant difference remained after accounting for all characteristics (OR 0.28, 95% CI 0.07–1.07).

A sensitivity analysis was conducted (data not shown) for the comparison between Mexican immigrants versus Mexicans with diabetes, controlling for the likelihood of the participant's usual place of care being on the opposite side of the border from the country of residence—which was common among Mexican immigrants with diabetes (25.7%) but not among Mexicans with diabetes (0.3%) (data not shown). After adjusting for this variable, there was no change in the likelihood of being undiagnosed between the two groups (OR 0.82, 95% CI 0.38–1.77). As with the full model above, there was no statistically significant difference between the two groups after adjusting for all variables, including having a usual place of care across the border.

In terms of the lower odds of being undiagnosed among non-Hispanic whites relative to Mexican immigrants with diabetes discussed above, most individual variables (considered separately) did little to explain this difference (data not shown). After adjusting for all variables, the difference between the two groups increased and remained statistically significant (from OR of 0.11 to 0.07, 95% CI 0.02–0.31). The difference in the odds of being undiagnosed between U.S.-born Hispanics versus Mexican immigrants increased after accounting for the younger average age of the former (from OR of 0.28 to 0.18, 95% CI 0.04–0.78; data not shown) and their higher education levels (OR 0.23, 95% CI 0.07–0.80). Accounting for healthcare access and utilization explained some of the difference between the two groups (OR 0.32, 95% CI 0.10–1.03), and the difference was no longer statistically significant. After accounting for all variables, however, a significant difference remained between the two groups (OR 0.21, 95% CI 0.05–0.88).

Table 3 presents the final model in order to illustrate the effects of individual explanatory variables on being undiagnosed among adults with diabetes, net of one another and controlling for border population. Younger adults with diabetes (aged 18 to 44 years) were significantly more likely to be undiagnosed than were older adults (aged 65 or older). Adults with diabetes who had a usual place of care were less likely to be undiagnosed than were those without a usual place of care. Other sociodemographic and healthcare-related characteristics were unassociated with the likelihood of being undiagnosed.

DISCUSSION

Among adults with diabetes living on the U.S.–Mexico border in 2001–2002, one in four (25.9%) was undiagnosed. Major disparities in diagnosis were evident between border subgroups with diabetes. Mexicans (43.8%) and Mexican immigrants (39.0%) with diabetes were substantially more likely to be undiag-

TABLE 3. Odds ratios of determinants of undiagnosed diabetes among adults with diabetes in the U.S.–Mexico border region, U.S.–Mexico Border Diabetes Prevention and Control Project Survey, 2001–2002 (*n* = 603)

Determinant	OR[a]	95% CI[b]
Border population (reference: Mexicans)		
U.S.-born Hispanics	0.28	0.07–1.07
Mexican immigrants	1.33	0.62–2.84
Non-Hispanic whites	0.10	0.03–0.35
Other U.S. adults	0.05	0.00–0.78
Age, years (Reference: ≥ 65)		
18 to 44	3.32	1.15–9.61
45 to 64	0.83	0.36–1.91
Women (Reference: men)	1.56	0.81–2.98
Education (Reference: none or primary school)		
Middle school	0.79	0.34–1.83
High school	1.30	0.34–4.95
More than high school	1.41	0.58–3.49
Obese (Reference: not obese)	0.91	0.51–1.61
Insured (Reference: uninsured)	1.54	0.62–3.85
Has usual place of care (Reference: no usual place of care)	0.45	0.20–0.99
Had doctor's visit in past 12 months (Reference: no visit)	0.53	0.26–1.08
Exposed to health information in past 12 months (Reference: no exposure)	0.57	0.29–1.13

[a] OR: odds ratio.
[b] CI: confidence interval.

nosed than U.S.-born Hispanics (14.7%) or non-Hispanic whites (6.6%) with diabetes. Mexicans with diabetes were also more likely to be undiagnosed than all U.S. adults with diabetes combined. Significant differences in the likelihood of being undiagnosed remained between all groups after adjustment for sociodemographic and healthcare-related covariates, with the exception of that between Mexicans and U.S.-born Hispanics, which was no longer statistically significant. These findings indicate a pressing need for improved screening and diagnosis for Mexican and Mexican immigrant adults with diabetes living in the border region.

Healthcare access and utilization did little to explain differences in diagnosis between Mexicans and U.S. groups with diabetes. This lack of explanatory effect may be due to fairly similar levels of access to care in these populations. This finding suggests that improvement in healthcare access and utilization alone among Mexicans may be insufficient to address disparities in the absence of improved access to quality screening services. Since the survey was conducted, Mexico has begun to implement wide-reaching healthcare reform through its *Seguro Popular* (Popular Health Insurance) program, which aims to fund health insurance for the uninsured, most of whom are low-income. In addition to universal healthcare coverage, the program intends to improve capacity for preventive care services like diabetes screening (24, 32). Given findings that healthcare access alone did little to explain disparities in diagnosis between Mexican and U.S. border populations with diabetes, efforts to improve system capacity around diabetes screening may be especially important for addressing these differences. Because the data were collected in 2001–2002, near the onset of these reforms, results may provide a baseline from which to assess the impact of healthcare quality improvements on diagnosis disparities in the region.

A portion of the difference in diagnosis for Mexicans with diabetes versus all U.S. adults and non-Hispanic whites with diabetes was explained by age. Because Mexican adults with diabetes are younger on average than U.S. adults with diabetes, their younger age may have resulted in greater missed screening by healthcare providers. Younger adults with diabetes in the region in general were less likely to be diagnosed than older adults, implying that efforts to improve diagnosis among younger Mexican adults could partially address disparities.

In contrast to Mexicans, healthcare access and utilization partially mediated the disparity in diagnosis between U.S.-born Hispanics and Mexican immigrants with diabetes. This finding suggests an urgent need to address the low levels of health insurance among Mexican immigrants. Mexican immigrants are not likely to experience the same improvements in access to healthcare promised under current healthcare reforms in either the United States or Mexico, given issues surrounding residency, citizenship, and occupational status. Without concentrated efforts to improve access to healthcare in this population, disparities in diagnosis are unlikely to be addressed. As with Mexicans, research on disparities in quality healthcare for Mexican immigrants versus other U.S. border groups with diabetes is an important next step for understanding disparities between these populations.

In addition to healthcare quality, other characteristics that influence diabetes screening and diagnosis could not be included in the analysis because of lack of available data, such as income, social support, knowledge of family history of diabetes, and return migration (for Mexicans) (22, 25, 33). Research on these and other individual-level characteristics may be important for understanding and addressing disparities in diabetes diagnosis among border groups.

Among adults with diabetes who were undiagnosed, substantially worse diabetes control was observed among Mexicans and Mexican immigrants versus all U.S. adults, U.S.-born Hispanics, and non-Hispanic whites. There was also a potentially greater benefit of diagnosis for improving metabolic control among Mexicans with diabetes in particular. These findings add to the urgency of the need for improved diagnosis efforts among Mexican border adults with diabetes. In the absence of such efforts, undiagnosed Mexicans may experience a relatively greater "legacy effect" from poor glucose control than U.S. adults with undiagnosed diabetes and some U.S. border subgroups, with heightened morbidity and mortality even after diagnosis and treatment initiation and intensification (34). This heightened risk for diabetes complications was especially concerning given the younger age of Mexican adults with diabetes, suggesting that Mexicans with undiagnosed diabetes may experience a longer period of exposure to poor glycemic control before disease management is initiated. Policies and programs that improve early screening and diagnosis among Mexicans may thus be especially important for improving border population health. Importantly, there was no difference in HbA1c between diagnosed and undiagnosed Mexican immigrants with diabetes. This suggests that diagnosis alone will be insufficient to improve glucose control in the absence of improvements in regular access to quality diabetes care in this population.

Notably, the prevalence of undiagnosed diabetes among all U.S. adults with diabetes living on the border was lower than has been found in the general U.S. population with diabetes in other studies—15% versus 30%, respectively (35). This may be due to greater awareness on the part of U.S. healthcare providers of the higher diabetes risk in the U.S. Hispanic versus non-Hispanic white populations (35). At the national level in the United States, Mexican Americans with diabetes (combining U.S.- and Mexico-born individuals) are less likely to be undiagnosed than non-Hispanic whites (22% and 34%, respectively), suggesting that healthcare providers may be responding to higher diabetes risk among the former (35). In an area with a large Hispanic population like the U.S. border region, levels of awareness may be even more pronounced and translate to lower population prevalence of undiagnosed diabetes. Results suggest that any increased awareness among healthcare providers or public health efforts have mainly benefitted U.S.-born Hispanics rather than Mexican immigrants. Although there is a pressing need to address disparities in diagnosis between regional subgroups, the relatively low prevalence of undiagnosed diabetes on the U.S. border suggests that the region may hold lessons for other areas of the country in terms of screening practices and public health strategies related to diabetes diagnosis.

This analysis was subject to limitations. The data are cross-sectional, which precludes causal interpretations. As data were collected only in the border region, it was not possible to compare diagnosis rates among border and non-border

areas in the two countries. However, qualitative comparison of the findings with those from national surveys in the United States, as discussed above, suggests that such comparisons may be an important step in future research. For the same reasons, results may not be generalizable to individuals in non-border areas of the United States or to Mexicans in other regions of Mexico. Finally, the data on which the analysis was based were collected in 2001–2002 and may not reflect current levels of diabetes diagnosis in border populations.

Despite these limitations, the study had significant strengths. The data set on which the study was based offered a rare opportunity to compare health outcomes in populations in the United States and Mexico. As a result, it was possible to identify differences in diabetes diagnosis among border populations and to make recommendations for targeting screening activities. The survey included metabolic measures, which enabled a comparison of risk for diabetes complications by diagnosis status in populations in the region. Undiagnosed diabetes represented a significant health problem along the U.S.–Mexico border in 2001–2002. Because Mexicans and Mexican immigrants with diabetes residing in the border region were more likely to be undiagnosed than other border groups, efforts to improve screening and diagnosis should focus on these populations. Improving healthcare access may partially address disparities in diagnosis evident between Mexican immigrants and non-Hispanic whites; however, given that access did little to explain differences in diagnosis between Mexican and U.S. groups with diabetes, findings suggest that improving the capacity and quality of diabetes screening in the Mexican border region may be a key avenue for future efforts to reduce disparities. Efforts to target younger adults with diabetes and younger Mexican adults in particular for improved screening may be especially important, given their higher risk of being undiagnosed. In the absence of targeted efforts to improve diabetes screening and diagnosis, results suggest that disparities may translate into differential risks of diabetes-related complications, morbidity, and mortality among border populations with diabetes. Findings from this analysis may have global implications for other border regions, especially those between countries with high levels of migration and variation in access to quality healthcare around diagnosis of chronic conditions like diabetes in regional subgroups.

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RESUMEN

Disparidades en la prevalencia de diabetes no diagnosticada en las poblaciones residentes en la frontera México-Estados Unidos

Objetivo. Comparar la prevalencia de diabetes no diagnosticada en la población con diabetes residente en la zona fronteriza entre México y los Estados Unidos; intentar explicar las diferencias entre grupos, e investigar las diferencias de los resultados metabólicos según la situación diagnóstica.

Métodos. Los datos proceden de la encuesta del Proyecto de Prevención y Control de la Diabetes en la Frontera México-Estados Unidos (2001–2002), que utilizó un diseño estratificado polietápico. La muestra incluyó a 603 adultos (≥ 18 años) con diabetes. Se definió como diabetes no diagnosticada una glucemia plasmática en ayunas ≥ 126 mg/dl sin diagnóstico previo. Se utilizó un modelo de regresión logística para comparar la probabilidad de que la diabetes no fuera diagnosticada en las poblaciones fronterizas. Los resultados metabólicos incluyeron la glucemia plasmática en ayunas, la hemoglobina glicosilada (HbA1c) y la presión arterial media.

Resultados. Uno de cada cuatro (25,9%) adultos diabéticos residentes en la zona fronteriza entre México y los Estados Unidos no había sido diagnosticado. La probabilidad de que los mexicanos (43,8%) y los inmigrantes mexicanos (39,0%) con diabetes no hubieran sido diagnosticados fue significativamente mayor en comparación con los hispanos nacidos en los Estados Unidos (15,0%; $P < 0,05$ para cualquiera de las comparaciones) o los blancos no hispanos (6,6%; $P < 0,001$ para cualquiera de las comparaciones). Los mexicanos con diabetes tenían una probabilidad mayor de no estar diagnosticados que los adultos estadounidenses con diabetes en su conjunto (14,7%; $P < 0,001$). Tras el ajuste para las covariables sociodemográficas y relacionadas con la atención de salud, se mantuvieron diferencias significativas entre todos los grupos con diabetes en cuanto a la probabilidad de que su diabetes no fuera diagnosticada, excepto cuando se compararon los mexicanos con los hispanos nacidos en los Estados Unidos. En los mexicanos se observó un peor control metabólico y mayores beneficios potenciales en cuanto al control como consecuencia del diagnóstico, en particular en comparación con los grupos estadounidenses con diabetes no diagnosticada.

Conclusiones. En la zona fronteriza entre los Estados Unidos y México, las actividades orientadas a mejorar el diagnóstico de la diabetes deben centrarse en las poblaciones mexicanas y de inmigrantes mexicanos.

Palabras clave Diabetes mellitus tipo 2; diagnóstico; disparidades en atención de salud; salud fronteriza; hispanoamericanos; Estados Unidos; México.