Ethnic and health correlates of diabetes-related amputations at the Texas-Mexico border

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ABSTRACT

Objective. To examine the association between diabetes-related lower-extremity amputation (LEA) and ethnicity, age, source of payment, geographic location, diabetes severity, and health condition in adults with diabetes mellitus type 2 living in border and non-border counties in Texas, United States of America, and to assess intra-border region geographic differences in post-LEA treatment.

Methods. This correlational study was based on secondary data from the 2003 Texas Inpatient Hospital Discharge Data. The sample consisted of individuals 45 years of age and older with type 2 diabetes who had undergone a nontraumatic LEA ($n = 5\,865$). Descriptive statistics and logistic regression analyses were applied.

Results. The following characteristics were predictors of LEA: being Hispanic or African American, male, ≥ 55 years old, and a Medicare or Medicaid user, and living in a border county. Persons with moderate diabetes and those who suffered from cardiovascular disease or stroke also had higher odds of undergoing an LEA. Post-LEA occupational therapy was significantly less prevalent among border residents (9.5%) than non-border residents (15.3%) (P < 0.001). **Conclusion.** Understanding the factors that influence diabetes-related LEA may lead to early detection and effective treatment of this disabling consequence of diabetes along the U.S.-Mexico border.

Key words

Amputation; border health; diabetes mellitus, type 2; minority health; Mexico; Texas; United States.

As observed by the World Health Organization (WHO), diabetes-related amputations cause unnecessary disability and mortality (1). Although up to 80% of

all diabetes-related lower-extremity amputations (LEAs) can be prevented with self-management health behaviors (1), this disabling condition is one of the most common causes of hospitalization for individuals with diabetes, and has great social, medical, and economic costs worldwide (1–5). LEA in persons with diabetes is a predictor of reduced quality of life (6), repeat amputation at five-year followup (7), and seven-year mortality (8).

Ethnic minority groups in the United States of America have significantly higher risk and prevalence of amputations, as well as higher associated mortality rates, than their non-Hispanic white counterparts (9–12). Lavery et al. identified a much higher prevalence of diabetes-related amputations in Hispanics (82.7%) versus African Americans (61.6%) and non-Hispanic whites (56.8%) in the United States (13).

This diabetes disparity is even more salient in the U.S.-Mexico border region, where U.S. border states have the highest Hispanic concentration in their popu-

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lations (14). The Pan American Health Organization (PAHO) has warned that diabetes is rising in the region, and significant efforts are under way to address this public health problem, which is of great concern in the Americas (15). Since 2001, PAHO has been coordinating a binational (United States-Mexico) initiative that has determined border diabetes prevalence rates and is working on developing prevention programs and activities in the border region (16). The diabetes ageadjusted death rate for Hispanics living in U.S. border counties (46.7 per 100 000 population) is three times higher than the rate for non-Hispanic whites living at the border (16.3 per 100 000 population) (17). Among all border residents, almost 16% suffer from type 2 diabetes, a higher rate than the national rate in both Mexico (14.9%) and the United States (13.9%) (15, 18). A study published in 2006 showed that in Texas the adjusted rate of diabetesrelated LEAs is significantly higher for border county residents (53.6 per 10 000) versus non-border residents (39.9 per 10 000) (19).

A key strategy in the planning process of diabetes prevention and control programs is the identification of predictors that influence the disease and its complications. Although previous studies have described rates of diabetes mortality and prevalence as well as amputation in the U.S.-Mexico border region, there is a paucity of data on risk factors for diabetes-related LEAs. Loss of a limb is a diabetes complication that leads to disability and death yet in most cases could have been prevented with self-care interventions (1, 20). Identification of these risk factors could help policy makers and health professionals design and implement more effective foot care interventions for groups most at risk of suffering from this disabling diabetes complication. The purpose of this study was to examine the association between LEAs and ethnicity, age, source of payment, geographic location, diabetes severity, and health condition in adults with type 2 diabetes living in border and nonborder counties in Texas, and to assess intra-border region geographic differences in post-LEA treatment.

MATERIALS AND METHODS

This correlational study was based on data from the 2003 Texas Inpatient Hospital Discharge Data (TIHDD). The

TIHDD dataset contains demographic, geographic, medical, and source-ofpayment data on hospital inpatient discharges from approximately 95% of state-licensed hospitals in Texas, coded by International Classification of Diseases, Ninth Revision, Clinical Modification (IDC-9-CM) and diagnosis-related group (DRG). Individuals identified for this study were 45 years of age and older, had type 2 diabetes (IDC-9-CM codes 250.00 and 250.02), and had undergone a nontraumatic LEA (IDC-9-CM codes 84.11–84.19) during 2003. Previous studies show that the prevalence of diabetes-related LEAs is significantly higher for individuals 45 years of age and older compared to younger individuals (12, 13, 19).

The study also examined relevant variables that influence diabetes-related LEAs, according to the literature, which is based mainly on non-Hispanic white samples (21-26). These variables included sex; age group, based on U.S. Centers for Disease Control and Prevention (CDC) categories (45-55, 56-64, and ≥ 65 years) (27); ethnic group (Hispanic, African American, non-Hispanic white, and other); source of payment for health care services (state government-funded programs, federal government-funded programs such as Medicare and Medicaid, employer-provided private insurance, and uninsured/self-pay patients); and geographic location (Texas border counties versus non-border counties). Border counties were defined as the 32 counties in Texas within 100 km of the U.S.-Mexico border. Income information was not available. Health variables included health condition factors and severity of diabetes (minor, moderate, and severe). Health condition factors included hypertension (IDC-9-CM codes 401–405); cardiovascular disease (CVD) (IDC-9-CM codes 410–414, 427, and 428); stroke (IDC-9-CM codes 431-434, 436, and 437); chronic obstructive pulmonary disease (COPD) (IDC-9-CM codes 491, 492, and 496); depression (IDC-9-CM codes 296 and 311); and renal disease (IDC-9-CM codes 580–586, 588, 589, and 593). The severity-of-illness variable in the TIHDD dataset were coded under four categories: minor, moderate, major, and extreme. Because very few individual in the study sample (2%) were classified as "extreme," the categories "major" and "extreme" were combined into one global category called "severe." The

TIHDD dataset does not provide information about how the reporting hospitals measured severity of illness. Summary statistics were calculated to describe the sample in terms of demographic and health conditions. Demographic characteristics and other indicators between border and non-border groups were compared using either the Pearson chi-square test or the Mann-Whitney U test, as appropriate. These statistical tests were used due to the non-normality of the data. Logistic regression analyses (unadjusted univariate and adjusted multivariate logistic regression) were used to test the association between the independent variables and LEA. Logistic regression analysis is presented as odds ratios (ORs) and 95% confidence intervals (CIs). The analysis was performed using SPSS for Windows, version 13.0 (SPSS Inc., Chicago, Ill., USA) (28). A *P* value < 0.05 was considered significant for all statistical tests conducted.

RESULTS

Out of the 204 776 patients listed in the TIHDD, a total of 5 865 persons 45 years of age and older had undergone a diabetes-related LEA. The number of persons with an LEA in the border area was 1 037 versus 4 828 in non-border counties. As shown in Table 1, significant differences were found between border and non-border individuals who had undergone an LEA by age (P = 0.001), ethnicity (P < 0.001), and source of payment (P < 0.001), but not by sex.

There were three times more Hispanics undergoing an LEA in border counties versus non-border areas (P < 0.001). In contrast, a statistically significant higher proportion of non-Hispanic whites and African Americans that had undergone an LEA resided in non-border counties versus border counties. There was also a higher proportion of older persons (\geq 65 years) with LEAs at the border area (72.71%) versus the same age group in non-border counties (66.76%) (P = 0.001).

Compared to persons with LEAs in non-border counties, two times more individuals at the border were Medicaid users (4.55% versus 9.64%, respectively). In contrast, the use of employer insurance was significantly more prevalent in non-border areas (14.00%) versus border locations (8.20%)

TABLE 1. Demographic and health characteristics of persons with type 2 diabetes that underwent a lower-extremity amputation in Texas in 2003, by area of residence (n = 5.865)

Characteristic	All		Border county residents ^a		Non-border county residents		
	No.	%	No.	% ^b	No.	%	P
Sex							0.651°
Men	3 062	52.21	489	47.16	2 514	52.07	
Women	2 803	47.79	548	52.84	2 314	47.93	
Ethnicity							< 0.001
Non-Hispanic white	2 595	44.25	106	10.22	2 489	51.55	
African American	760	12.96	3	0.29	757	15.68	
Hispanic	2 145	36.57	845	81.49	1 300	26.93	
Other	365	6.22	83	8.00	282	5.84	
Age (years)							0.001 ^d
45–54	597	10.18	100	9.64	497	10.29	
55-64	1 291	22.01	183	17.65	1 108	22.95	
≥ 65	3 977	67.81	754	72.71	3 223	66.76	
Source of payment							< 0.001
Employer insurance	759	12.97	85	8.20	674	14.00	
Medicaid	319	5.45	100	9.64	219	4.55	
Medicare	4 465	76.32	810	78.11	3 655	75.94	
Uninsured/self-pay	165	2.82	35	3.38	130	2.70	
Other	142	2.43	7	0.68	135	2.80	
Severity of diabetes							0.400 ^d
Minor	978	16.7	166	17.0	812	83.0	
Moderate	3 956	67.5	698	17.6	3 258	82.4	
Severe	927	15.8	171	18.4	756	81.6	
Health condition							
Hypertension	3 626	61.82	656	63.26	2 970	61.52	0.294 ^c
Cardiovascular disease	3 275	55.84	571	55.06	2 704	56.01	0.579 ^c
Stroke	445	7.59	85	8.20	360	7.46	0.414 ^c
Chronic obstructive							
pulmonary disease	695	11.85	90	8.68	605	12.53	< 0.001°
Depression	112	1.91	20	1.93	92	1.91	0.961 ^c
Renal disease	211	3.60	27	2.60	184	3.81	0.058 ^c

^a Those living in any of the 32 Texas counties within 100 km of the U.S.-Mexico border.

The majority (67.5%) of all individuals who had undergone an LEA were classified as having moderate diabetes. There were no statistically significant differences in severity of illness between border and non-border patients.

The prevalence of hypertension, CVD, stroke, depression, and renal disease was similar for both border and non-border residents that had undergone an LEA. There was a statistically significant difference between the two groups in prevalence of COPD, which was more common among individuals living in non-border versus border counties (12.53% versus 8.68%; P < 0.001).

Table 2 presents detailed results from the univariate (unadjusted) and multivariate (adjusted) logistic regression analyses. In the multivariate analyses, males were more likely to have undergone an LEA than females. Being Hispanic or African American was significantly correlated with LEA. Age was another factor significantly correlated with amputations: persons between the ages of 55 and 64 years were more likely than younger individuals (45–54 years of age) or older persons (65 and older) to have been discharged from the hospital with a diabetes-related LEA.

Source of payment was also examined as a risk factor for LEA. Multivariate analyses indicated that persons with diabetes that had Medicare or Medicaid were more likely to have had an LEA than those who had insurance from an employer, paid their own expenses, or were uninsured.

Border residents were also more likely to undergo an LEA than those not living in the border counties. Adjusted logistic analyses also showed that patients classified as having moderate diabetes had a statistically significant higher probability of having an LEA than those considered as having minor diabetes. However, the probability of undergoing an LEA was statistically significantly higher for those classified as having moderate

diabetes than those classified as having severe or minor diabetes.

In addition, persons diagnosed with CVD or stroke were more likely to have an LEA than those who were not diagnosed with either of those diseases. Depression was also a statistically significant predictor of LEA. However, data indicate that persons suffering from depression were less likely than those without depression to have an LEA. COPD was not significantly associated with LEA.

As shown in Table 3, a significantly higher proportion of persons not living in border counties received post-LEA occupational therapy versus those residing along the border (P < 0.001). However, a statistically significant difference was not found for physical therapy between border and non-border individuals.

DISCUSSION

To the best of the authors' knowledge, this study is the first in the United Sates to determine personal and health correlates to LEA in an at-high-risk group living in border and non-border counties in the state of Texas.

The study results indicated that Hispanics and African Americans with type 2 diabetes are at greater risk of having an LEA than their non-Hispanic white counterparts. This result is consistent with Young et al. (10), who studied patients with nephropathy and found that amputees were more likely to be Hispanic or African American than non-Hispanic white. Other studies, however, have not confirmed a significant association between diabetes-related amputations and ethnicity (29, 30). Conflicting results in the literature suggest that more research examining confounding factors in the association of ethnicity with LEAs is needed. Previous study results also underscore the importance of exploring the influence of ethnic disparities in accessing preventive medical care among persons with diabetes (10, 29, 31).

Another finding in the current study was that the risk for LEAs is greater for males than for females, and it increases with age. These results are consistent with other research (10, 19, 21, 32, 33). However, a study conducted by Nelson et al. among Pima Indians did not show a significant association between LEAs and aging (34). The discrepancy between the latter study and the current findings

^b Valid percentages excluding missing values

^c Based on Pearson chi-square test (P < 0.05).

d Based on Mann-Whitney U test (P < 0.05).

TABLE 2. Odds ratios for risk factors for lower-extremity amputation (LEA) among border and non-border residents with type 2 diabetes that underwent an LEA in Texas-Mexico border region in 2003 (n = 5 865)

		Unadjusted		Adjusted			
Risk factor	ORa	95% CI ^b	Р	OR	95% CI	Р	
Sex							
Men	1.47	1.39-1.55	< 0.001	1.51	1.43-1.59	< 0.001	
Women ^c	1.00			1.00			
Ethnicity							
Hispanic	1.51	1.43-1.60	< 0.001	1.58	1.48-1.69	< 0.001	
African American	1.08	1.00-1.17	0.061	1.22	1.12-1.33	< 0.001	
Other	1.13	1.01-1.26	0.037	1.14	1.02-1.28	0.020	
Non-Hispanic white ^c	1.00			1.00			
Age							
≥ 65	2.10	1.93-2.29	< 0.001	1.38	1.24-1.53	< 0.001	
55–64	1.61	1.46-1.77	< 0.001	1.48	1.34-1.64	< 0.001	
45–54 ^c	1.00			1.00			
Source of payment							
State government-funded programs	1.01	0.84-1.21	0.934	0.97	0.81-1.16	0.751	
Medicare	2.07	1.92-2.24	< 0.001	1.99	1.81-2.19	< 0.001	
Medicaid	1.51	1.33-1.73	< 0.001	1.49	1.30-1.70	< 0.001	
Uninsured/self-pay patients	0.94	0.80-1.12	0.500	0.90	0.76-1.07	0.247	
Employer-provided private insurance ^c	1.00			1.00			
Severity of diabetes							
Severe	0.78	0.71-0.86	< 0.001	0.62	0.56-0.68	< 0.001	
Moderate	1.21	1.13-1.30	< 0.001	1.10	1.03-1.19	0.008	
Minor ^c	1.00			1.00			
Region							
Border counties ^d	1.42	1.32-1.52	< 0.001	1.10	1.02-1.19	0.014	
Non-border counties ^c	1.00			1.00			
Comorbid conditions/complications ^e							
Hypertension	1.00	0.95-1.05	0.982	0.92	0.87-0.97	0.002	
Cardiovascular disease	1.37	1.30-1.44	< 0.001	1.29	1.22-1.36	< 0.001	
Stroke	1.43	1.29-1.57	< 0.001	1.42	1.28-1.57	< 0.001	
Chronic obstructive pulmonary disease	0.99	0.91-1.07	0.734	0.94	0.86-1.02	0.126	
Depression	0.47	0.39-0.57	< 0.001	0.56	0.46-0.67	< 0.001	
Renal disease	0.98	0.85-1.12	0.761	1.09	0.94-1.25	0.252	

^a OR: odds ratio.

TABLE 3. Differences in post–lower-extremity amputation (LEA) treatment between border and non-border residents that underwent an LEA in Texas in 2003 ($n = 5\,865$)

Treatment	All		Border county residents ^a		Non-border county residents		
	No.	% ^b	No.	% ^b	No.	% ^b	Pc
Physical therapy							
Yes	1 908	32.5	322	31.1	1 586	32.9	0.262
No	3 957	67.5	715	68.9	3 242	67.1	
Occupational therapy							
Yes	838	14.3	98	9.5	740	15.3	< 0.001
No	5 027	85.7	939	90.5	4 088	84.7	

^a Those living in any of the 32 Texas counties within 100 km of the U.S.-Mexico border.

may be due to methodological differences, as the study by Nelson et al. was based on a very small sample (n = 80).

The current study also found that persons living in a border county and hav-

ing Medicare/Medicaid were more likely to undergo an LEA than non-border residents and persons who were uninsured/self-pay or had private (employerprovided) insurance. These results may

reflect the fact that some LEA procedures 1) may not be fully covered by private insurance and 2) may not be affordable for uninsured/self-pay patients. The discrepancy in LEA prevalence by geo-

^b CI: confidence interval.

^c Reference group.

^d Within 100 km of the U.S.-Mexico border.

^e Reference group was "no disease."

^b Valid percentages excluding missing values.

^c Based on Pearson chi-square test (P < 0.05).

graphic area may also be partly attributable to regional differences in care and treatment. According to previous research with Medicare patients (35-37), the procedures for many types of surgery, including LEA in persons with diabetes, vary highly across geographic areas. A study at a teaching hospital in the Texas border area found that people with diabetes who had no insurance were twice as likely to suffer from limb amputations as those with some form of insurance (37). These findings suggest that geographic variations in LEA prevalence may be explained by differences in population characteristics, insurance benefits, surgery capacity, and care and treatment styles. More in-depth investigation into the influence of health insurance benefits, health care access, and regional care styles on the prevalence of LEAs in the U.S.-Mexico border region is warranted.

This study also found that having a diagnosis of CVD or stroke were risk factors for undergoing an LEA. These findings concur with previous research (7, 10, 21, 24, 26, 39–41) and suggest that persons with diabetes with either of these health conditions should be 1) closely monitored by their clinicians for the development of foot ulcers and 2) provided with foot care education.

Some findings in this study are intriguing. First, the results indicate that the patients classified as having moderate diabetes were more likely to undergo an LEA than those classified as having minor or severe diabetes. This finding contradicts previous research that showed an association between diabetes complications and LEAs (21–23, 26). Second, in contrast with the literature (16), the present study indicates that individ-

uals with depression were at lower risk of undergoing an LEA than those without depression. As acknowledged below with regard to possible study limitations, these conflicting results may be partly attributable to errors in the reporting process. According to TIHDD, there might be errors in the secondary dataset "caused by the inability of the hospital to communicate complete data due to form constraints, subjectivity in the assignment of codes, system mapping, and normal clerical error" (42). Another interesting finding in the current research was the lack of a significant association between renal disease and LEAs, contradicting previous studies (39-41). This discrepancy may be related to the population examined. Much of the previous research included dialysis patients in their study samples, whereas for the current research it was not possible to determine precise renal stage in the population studied. Further research is warranted to examine the association between renal disease stages and LEAs.

The current study results reveal a disparity in post-LEA treatment, with a statistically significantly lower proportion of border county residents receiving treatment from occupational therapists (which have a key role in post-LEA rehabilitation) compared to non-border residents. No reports examining ethic disparities in post-LEA treatment were found in the literature. The availability of rehabilitation services for those at the border undergoing LEAs should be further examined. Research is also warranted to identify any personal care or health care factors associated with rehabilitation in persons with diabetesrelated LEAs living in border and nonborder counties.

This study has several limitations. First, causal inferences cannot be drawn from the results, because the research is neither prospective nor experimental. Second, the study findings may not be generalizable to other populations because the secondary data used in the research were limited to individuals with access to a hospital and residence in the state of Texas. In addition, the secondary data do not report additional variables identified in the literature as predictors of diabetes-related amputations, such as duration of illness, income, medication adherence, poor foot behaviors, insulin use, and level of glycosylated hemoglobin 1Ac. Another potential study limitation is the fact that the secondary data do not specify if patients had ever been discharged with previous amputations. Therefore, this study could not determine if past history of amputations contributed to the significant prevalence of LEAs indicated in the results. Finally, as mentioned above, it was not possible to verify if there were any hospital data reporting errors or to assess any other aspect of data quality control for the secondary dataset.

In conclusion, this exploratory study aimed to contribute to the scarce border literature examining personal and health factors associated with diabetes-related amputations. Understanding predictors of limb loss in adults with type 2 diabetes is critical for effectively targeting highrisk groups along the border. Correlates identified in this study may help health professionals, policy makers, and researchers develop more effective strategies for early detection and tailored interventions in the prevention of this disabling consequence of diabetes affecting U.S.-Mexico border residents.

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RESUMEN

Correlatos étnicos y de salud de las amputaciones relacionadas con la diabetes en la frontera entre Texas y México *Objetivo.* Analizar la asociación entre las amputaciones de extremidades inferiores (AEI) relacionadas con la diabetes y el grupo étnico, la edad, la procedencia del pago, la ubicación geográfica, la gravedad de la diabetes y el estado de salud de los adultos que padecen diabetes tipo 2 residentes en los condados fronterizos y no fronterizos de Texas (Estados Unidos de América), y evaluar la diferencias geográficas dentro de la zona fronteriza en cuanto al tratamiento posterior a la amputación.

Métodos. Este estudio correlacional se basó en datos secundarios procedentes de la información de egreso de pacientes hospitalizados en Texas durante el año 2003. La muestra estuvo integrada por personas de 45 años o mayores con diabetes tipo 2, que habían sido sometidas a la amputación no traumática de una extremidad inferior $(n = 5\,865)$. Se aplicaron estadística descriptiva y análisis de regresión logística.

Resultados. Las siguientes características constituyeron factores predictivos de AEI: ser hispano o afroestadounidense, hombre, de 55 años o mayor, beneficiario de Medicare o Medicaid, y residente en un condado fronterizo. Las personas con diabetes moderada que padecían enfermedades cardiovasculares o habían sufrido un accidente cerebrovascular también tenían una mayor probabilidad de ser sometidas a una AEI. La terapia ocupacional posterior a la amputación fue significativamente menos prevalente entre los residentes fronterizos (9,5%) que entre los no fronterizos (15,3%) (P < 0.001).

Conclusiones. La comprensión de los factores que influyen en las AEI relacionadas con la diabetes puede conducir a la detección temprana y el tratamiento eficaz de esta secuela discapacitante en la zona fronteriza entre los Estados Unidos y México.

Palabras clave

Amputación; salud fronteriza; diabetes mellitus tipo 2; salud de minorías; México; Texas; Estados Unidos.