A Lack of Decline in Major Nontraumatic Amputations in Texas: Contemporary Trends, Risk Factor Associations, and Impact of Revascularization

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EPIDEMIOLOGY/HEALTH SERVICES RESEARCH

OBJECTIVE

Nontraumatic major lower extremity amputations (LEAs) have been reported to be declining nationally; however, trends in Texas have been less well described. We evaluated demographic and clinical risk factors and revascularization associations for LEAs by using inpatient hospital discharge data in Texas from 2005 to 2014.

RESEARCH DESIGN AND METHODS

Inpatient hospital discharge data were obtained from the Texas Center for Health Statistics. Multivariate logistic regression analyses were performed to evaluate clinical, ethnic, and socioeconomic risk factors associated with LEA. The impact of revascularization (surgical and/or endovascular) on LEA was analyzed.

RESULTS

Between 2005 and 2014, of 19,939,716 admissions, 46,627 were for nontraumatic major LEAs. Over time, LEAs were constant, and revascularization rates during index admission declined. The majority of LEAs occurred in males and in individuals aged 60–79 years. Risk factors associated with LEA included diabetes, peripheral arterial disease, chronic kidney disease, and male sex ($P < 0.001$). Insurance status, hyperlipidemia, coronary artery disease, and stroke/transient ischemic attack were associated with lower odds of amputation ($P < 0.001$). Hispanic (odds ratio [OR] 1.51 [CI 1.48, 1.55], P value <0.001) and black (OR 1.97 [CI 1.92, 2.02], P value <0.001) ethnicities were associated with a higher risk for amputation when compared with non-Hispanic whites. Revascularization, either surgical or endovascular (OR 0.52 [CI 0.5, 0.54], P value <0.001), was also associated with lower odds for amputation.

CONCLUSIONS

Amputation rates in Texas have remained constant, whereas revascularization rates are declining. A higher risk for LEA was seen in minorities, including Hispanic ethnicity, which is the fastest growing demographic in Texas. Revascularization and having insurance were associated with lower odds for amputation.

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Patients with diabetes-related foot ulcers have a higher risk of death than those without, and approximately one in five of those patients requires some level of amputation. Peripheral arterial disease (PAD) independently increases the risk of major nontraumatic lower extremity amputations (LEAs) in the U.S. (1,2). LEAs are associated with significant morbidity and mortality. Although nationwide LEA rates were previously declining, new trends have shown that they are now on the rise (3–5). In addition, significant racial, geographic, and socioeconomic disparities have been described (6–11). Increases in endovascular and surgical revascularization have been associated with a decline in LEAs; however, this trend remains to be explored in Texas (12).

The incidence of LEAs is higher in the southern regions of the U.S., including the state of Texas. Texas is notable for high rates of underinsured individuals, increasing prevalence of diabetes, heterogeneity in regional poverty, and a growing Hispanic population (13). Prior studies have demonstrated that specific regions within Texas have relatively higher rates of LEAs (14,15). The purpose of the present analysis was to define the temporal trends and risk factor associations and assess the impact of revascularization therapy for LEAs in Texas.

RESEARCH DESIGN AND METHODS

This study used inpatient hospital discharge data obtained from the Texas Center for Health Statistics for the years 2005–2014. This data set contains demographic, medical, geographic, and source-of-payment information on hospital inpatient discharges from all state-licensed hospitals except with those who are exempt from reporting. Exempt hospitals include those located in a county with a population <35,000, those located in a county with >35,000 but with <100 licensed hospital beds, and those who do not seek insurance payment from government reimbursement. The hospitals in this data set represent ~85% of all hospitals in Texas (16). The data set is coded in accordance with ICD-9, Clinical Modification.

The number of LEAs in Texas was determined by ICD-9 coding for amputation. The list of diagnosis codes is shown in Supplementary Table 1. A major LEA was defined as involving the proximal part of the foot, leg (below the knee), thigh (above the knee), and hip disarticulation. Endovascular revascularization was determined by evaluating codes for peripheral atherectomy, peripheral angioplasty, and peripheral drug-eluting and nondrug-eluting stent placement. Surgical revascularization was determined by coding for lower extremity bypass surgery. Insurance status was defined by those admissions with Medicare, Medicaid, or private insurance as first source of payment. Uninsured status were those categorized as self-pay or charity, indigent, or unknown.

Major LEA and revascularization annual incidence rates per 100,000 population of Texas were calculated. Adjusted multivariate logistic regression analyses were used to test the association between the independent variables and LEA. Logistic regression analyses are presented as odds ratios (ORs) and 95% CIs. Univariate Poisson regression models with adjustment for overdispersion were used to assess the significance of trends with time. The analysis was performed using SAS 9.4 and R (version 3.5.1). All statistical testing was two sided with a significance level of 5%.

RESULTS

Baseline Characteristics

Between 2005 and 2014, of 19,939,716 admissions, 46,627 were for nontraumatic major LEAs. Table 1 describes the baseline characteristics of individuals who underwent an LEA. The majority of major LEAs occurred in individuals aged 60–79 years. Sixty-one percent occurred in males, 68% had diabetes, and 69% had PAD. Thirty-four percent of admissions for LEA were Hispanic, 21.5% were non-Hispanic black, and 38.7% were non-Hispanic white. Of these admissions, 10% underwent revascularization (endovascular and/or bypass), 7.7% underwent endovascular therapy, and 3% underwent bypass surgery during index admission.

Trends in Major Amputations and Revascularization Over Time

Figure 1 outlines the temporal trends of major amputations and revascularization from the years 2005–2014. Amputation rates remained stable (~250 per 100,000 admissions) over time. Revascularization (both endovascular and/or surgery) during index admission for amputation declined over time ($P < 0.001$).

Multivariate Analysis for Major Amputations

Significant risk factors associated with major LEA included chronic kidney disease (CKD) (OR 1.47 [CI 1.43, 1.51], *P* value <0.001), diabetes (OR 2.39 [CI 2.34, 2.44], *P* value <0.001), and male sex (OR 1.69 [CI 1.66, 1.72], *P* value <0.001). The strongest association for major LEA was PAD (OR 78.41 [CI 76.63, 80.23], *P* value <0.001). Having insurance (OR 0.77 [CI 0.75, 0.8], *P* value <0.001), hyperlipidemia (OR 0.71 [CI 0.7, 0.73], *P* value <0.001), coronary artery disease (CAD) (OR 0.79 [CI 0.77, 0.81], *P* value <0.001), and stroke/transient ischemic attack (TIA) (OR 0.37 [CI 0.34, 0.41], *P* value <0.001) were associated with lower odds of amputation. Revascularization, which includes both surgery and/or endovascular therapy (OR 0.52 [CI 0.5, 0.54], *P* value <0.001), was also associated with lower odds for LEA (Table 2). Hispanic (OR 1.51 [CI 1.48, 1.55], *P* value <0.001) and black (OR 1.97 [CI 1.92, 2.02], *P* value <0.001) ethnicities were associated with a higher risk for amputation when compared with non-Hispanic whites (Table 3).

CONCLUSIONS

In this study, we evaluated the temporal incidence of and risk factor associations for LEAs in Texas over the years 2005–2014. We demonstrate the following key findings: *1*) LEA rates in Texas have remained stable; *2*) revascularization rates during the index admission are low; *3*) traditional risk factors of diabetes, PAD, CKD, and male sex are associated with higher odds for amputation; *4*) Hispanic and black ethnicity portends a higher risk as well; and *5*) having insurance or undergoing revascularization are associated with lower odds for LEA.

Nationally, amputation rates declined in the previous decade (7,9,12); however, similar to what our study has demonstrated, some studies have shown that they have now been increasing since 2009 (3,4). Geiss et al. (3) recently evaluated trends in major and minor LEAs in patients with and without diabetes and found that although the rate decreased from 2000 to 2009, the trend has reversed from 2009 to 2015. This change in amputation rates was primarily due to an increase in amputation rates among men, young and middle aged

Table 1—Demographics and comorbidities of individuals who underwent a major amputation

Clinical variable	Major amputation (*n*, %)
	n = 46,627
Age (years)	
20–39	1,929 (4.1)
40–59	13,655 (29.3)
60–79	22,437 (48.1)
>80	8,606 (18.5)
Race/ethnicity	
Hispanic	15,934 (34.2)
Non-Hispanic black	10,023 (21.5)
Non-Hispanic white	18,063 (38.7)
Other[1]	2,607 (5.6)
Male sex	28,442 (61.0)
Diabetes	31,874 (68.4)
Hyperlipidemia	14,278 (30.6)
Hypertension	16,918 (36.3)
CKD	18,622 (39.9)
Smoker	5,759 (12.4)
CAD	16,285 (34.9)
PAD	32,305 (69.3)
Critical limb ischemia	21,066 (45.2)
Stroke/TIA	529 (1.1)
Congestive heart failure	2,801 (6.0)
Chronic obstructive pulmonary disease	5,975 (12.8)
Insurance (private, Medicare, Medicaid)	41,912 (89.9)
Medicaid	4,028 (8.6)
Medicare	31,543 (67.6)
Private	6,020 (12.9)
Uninsured	3,749 (8.0)
Other	1,287 (2.8)
Peripheral intervention during index admission	3,598 (7.7)
Bypass intervention during index admission	1,409 (3.0)
Revascularization (bypass and/or peripheral intervention during index admission)	4,730 (10.1)

[1]Other includes non-Hispanic individuals who identified themselves as two or more races, American Indian or Alaskan Native, Asian, Native Hawaiian, or other Pacific Islander.

(18–64 years of age) and in minor amputations. The Centers for Disease Control and Prevention also report an increase in hospitalization rates for nontraumatic LEAs in patients with diabetes above the age of 18 years from 2009 to 2015 (4). The reason for the reversal in amputation trends is unclear and remains to be explored.

Many studies have demonstrated that certain geographic areas in the country are disproportionately affected by LEAs. One of the first studies that evaluated significant geographic variation in amputation rates was published by Wrobel et al. (10). The authors found a higher rate of geographic variation in amputation rates among Medicare patients from 1996 to 1997 with diabetes versus those without diabetes, despite adjusting for age, sex, and race. Goodney et al. demonstrated significant regional variation in rates of amputation, up to 10-fold differences across regions in the U.S. (8,14). For example, between 2003 and 2007, there was a 10-fold difference in the rate of leg amputations, ranging from 0.33 per 1,000 Medicare beneficiaries in Provo, Utah, to 3.29 per 1,000 beneficiaries in McAllen, Texas (14). From 2007 to 2009, there was <1 amputation per 10,000 Medicare patients in Mesa, Arizona, but there were 23 per 10,000 patients in McAllen, Texas (8). Margolis et al. (11) evaluated geographic variation and clustering of LEAs among Medicare beneficiaries with diabetes between 2006 and 2008 and found excessively high rates along contiguous portions of southeast Texas, southern Oklahoma, and Louisiana. Even within the state of Texas, there is regional heterogeneity in number of amputations, with previous studies citing that the Texas-Mexico border and South Texas have higher rates of amputation compared with the rest of the state of Texas (11,15).

Prior studies have attempted to better understand the variability of amputation rates across the U.S. Common themes have suggested that socioeconomic status and race play key roles in risk for LEA. Eslami et al. (17) evaluated patients who underwent LEAs from the Nationwide Inpatient Sample data set from 1999 to 2002 and found that patients with Medicaid and Medicare were at higher risk for undergoing an amputation. In addition, as patient income decreased, the rate of amputation increased. The Margolis et al. (11) study noted geographic clustering of LEAs among Medicare beneficiaries with diabetes and reported that these regions tended to have lower socioeconomic status, higher percentages of African Americans, and a higher prevalence and mortality associated with a diabetic foot ulcer. A study evaluating amputation rates in northern Illinois also showed a higher risk for amputation rate among individuals who lived in lower-income communities (18). Both studies also noted racial disparities in amputation rates, with blacks and Hispanics disproportionately affected by amputations. Although our study did not evaluate the relationship between income and LEA risk, we found that ~16% of individuals who had a LEA in our analysis had Medicaid or no insurance, suggesting low income status.

Consistent with prior publications, our analysis also demonstrated that Hispanic and black ethnicities were independently associated with higher odds for major amputation. In addition, studies have shown that the severity (higher level) of amputation was also worse among minorities (17–21). Racial and geographic disparities in Texas have been described, and it is known that diabetes-related LEAs in South Texas are higher in blacks and Mexican-Americans (22). Potential reasons for such disparities include, in part, the observation that minorities present to the hospital with advanced disease and are less likely to undergo revascularization. In a study by Morrissey et al. (23), Hispanic patients were more likely to

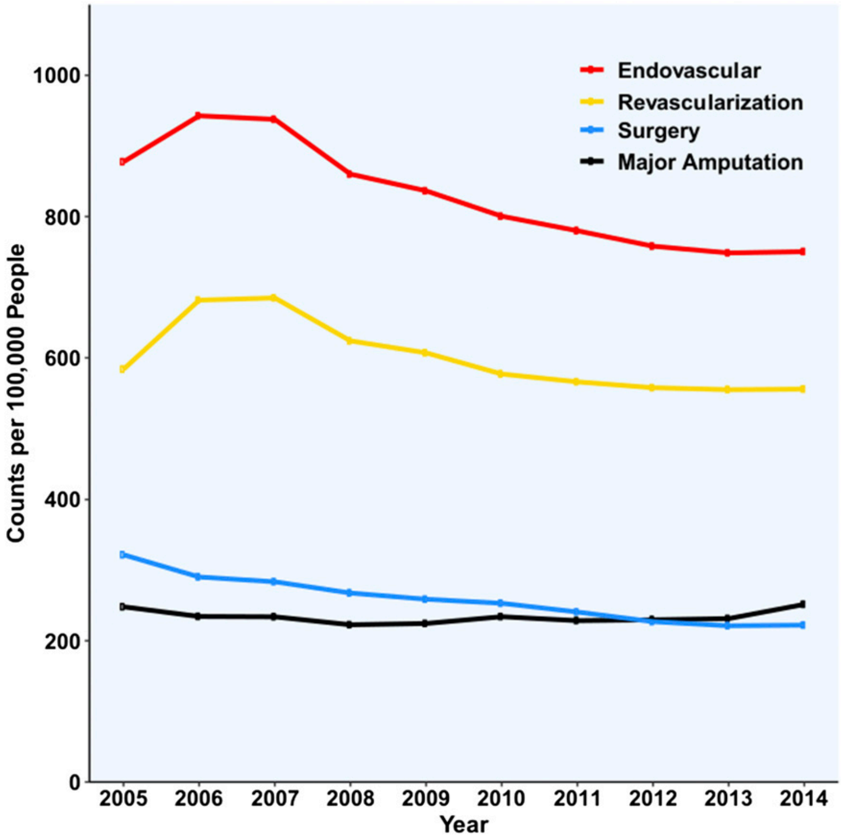

Figure 1—Annual rate of major amputations and revascularization (bypass and endovascular). This figure illustrates temporal rates of major amputations and revascularization procedures per 100,000 people. The red line includes both surgery and endovascular revascularization. Major amputation rates are unchanged over time. Revascularization rates are declining ($P < 0.001$).

present to the hospital with limb-threatening lower extremity ischemia than non-Hispanic whites, thus lowering their opportunity to undergo revascularization. In addition to traditional socioeconomic and clinical risk factors that disproportionately affect Hispanics, the authors mention cultural barriers, such as reliance on self-care methods and distrust of the medical system, as potential contributors that have not been fully explored. Furthermore, although the genetic influence on the development of PAD has not been completely elucidated, it is possible that there are genetic differences in how vascular disease manifests in Hispanics. These findings are important, as Mexican-Americans are the fastest growing demographic in Texas and the second fastest in the U.S. (24).

Our study demonstrated that undergoing revascularization during index hospitalization was associated with a reduced risk of undergoing an LEA. This is congruent with current literature regarding revascularization and amputations. Goodney et al. (8) demonstrated that in regions with the highest amputation rates, patients underwent 54% fewer open or endovascular therapeutic revascularizations for each amputation, supporting the theory that areas with few vascular specialists have a higher population-based risk of amputation. Ho et al. (25) evaluated Medicare claims data and showed that in areas with a high number of vascular surgeons and interventional radiologists, there were lower amputation rates. More recently, Agarwal et al. (12) found that rates of major amputation declined with a concurrent rise in endovascular procedures. Although the relationship between revascularization and reduced risk for amputation are associative in these studies, improving perfusion is a crucial component to reducing LEAs.

Nationally, endovascular therapy is increasing, yet this was not seen in our analysis of Texas hospital discharge data. There are a few possibilities as to why this is occurring. Prior studies have shown that attempts at revascularization are more prevalent in patients with private/HMO insurance rather than with Medicare or Medicaid (17). According to a United Census Bureau report, the percentage of individuals without insurance in Texas was 16.6%, the highest in the country. The demographic group with the highest percentage of individuals without health insurance is Hispanics. In our analysis, only 13% of individuals who underwent an amputation had private insurance (26). Second, research has shown that areas with few vascular specialists have a higher

Table 2—Multivariable adjusted logistic regression for major amputations, *n* = 19,939,716

Variable	OR	CI 95%	*P* value
Diabetes	2.39	2.34, 2.44	**<0.001***
CKD	1.47	1.43, 1.51	**<0.001***
Hyperlipidemia	0.71	0.7, 0.73	**<0.001***
Hypertension	1.01	0.98, 1.03	0.59
PAD	78.41	76.63, 80.23	**<0.001***
Smoker	1.07	1.04, 1.11	**<0.001***
Race/ethnicity (Hispanic)†	1.51	1.48, 1.55	**<0.001***
Race/ethnicity (non-Hispanic black)†	1.97	1.92, 2.02	**<0.001***
Male sex	1.69	1.66, 1.72	**<0.001***
Insurance (private, Medicare, or Medicaid)	0.77	0.75, 0.8	**<0.001***
CAD	0.79	0.77, 0.81	**<0.001***
Stroke TIA	0.37	0.34, 0.41	**<0.001***
Congestive heart failure	1.09	1.04, 1.13	**<0.001***
Chronic obstructive pulmonary disease	1.10	1.07, 1.13	**<0.001***
Year	0.99	0.98, 0.99	**<0.001***
Age >65 years (senior)	1.18	1.16, 1.21	**<0.001***
Revascularization (surgical and/or endovascular)	0.52	0.5, 0.54	**<0.001***

Significant *P* values appear in boldface type. **P* value <0.05. †Non-Hispanic white is the reference group.

Table 3—Risk of major amputation by race/ethnicity

Variable	OR	95% CI	*P* value
Race/ethnicity (Hispanic)†	1.92	1.88, 1.96	**<0.001***
Race/ethnicity (other)‡	1.11	1.06, 1.15	**<0.001***
Race/ethnicity (non-Hispanic black)†	2.38	2.32, 2.44	**<0.001***

Significant *P* values appear in boldface type. **P* value <0.05. †Non-Hispanic white is the reference group. ‡Other includes non-Hispanic individuals who identified themselves as two or more races, American Indian or Alaskan Native, Asian, Native Hawaiian, or other Pacific Islander.

population-based risk for amputation (8,25). Although no prior study has looked at intensity of vascular care within regions of Texas, we have shown that revascularization is potentially underutilized, which may partially explain the higher rate of amputations in certain areas. Third, diabetes is widely prevalent in Texas, in particular among Hispanics and those residing in South Texas. A cohort of Mexican-Americans residing in South Texas reported a prevalence of diabetes of 30%, with more than half of those undiagnosed and untreated (27). Mexican-Americans are more likely to present to the hospital with late-stage findings of critical limb ischemia (23). Untreated diabetes coupled with a lack of access to care due to uninsured status are likely to be important factors in the epidemic of LEAs in Texas.

Limitations of Study

Our study has several important limitations. Given the data are extrapolated from a large database, one cannot exclude errors in coding. This data set keeps track of hospital admissions and not patients. Although a patient may not have had a revascularization during index admission, it is possible they had one prior to admission to the hospital or at an outpatient elective procedure. However, it should be noted that data outlining contrasting national trends were also derived from inpatient administrative data sets (12). Lastly, not all hospitals in Texas contribute data to this data set. However, the data set represents ~85% of all hospitals in Texas and, in our opinion, contains enough data to extrapolate amputation trends.

Conclusion

LEAs are a preventable complication of diabetes and PAD. In Texas, major LEAs are not declining. Although revascularization was associated with a reduced risk for amputation, our data show this therapy was underutilized in the state. Hispanics, in particular, are more likely to undergo an amputation. Further studies to understand the disparities in access to care, in particular access to revascularization procedures in the Hispanic population in Texas, are needed.

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