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Health Care Resource Distribution of Texas Counties With High Rates of Leg Amputations

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ABSTRACT

Background: Lower extremity amputation rates associated with peripheral arterial disease in Texas are high and vary disproportionately among different populations. We sought to assess the impact of socioeconomic status and health care resource distribution on the geographic prevalence of lower extremity amputation in Texas counties.

Materials and methods: We collated 2005-2009 data on all 254 Texas counties. The primary outcome was the number of nontraumatic lower extremity amputations. Population-adjusted regressions identified factors that could explain increasing amputation rates.

Results: We identified 33 counties with population-weighted amputation rates in the highest 25%. These counties had higher rates of diabetes, larger populations of people categorized as black, fewer health care resources, and lower health care utilization. In the presence of more emergency room visits, dual Medicare/Medicaid eligibility decreased total amputations. In counties with more than 70% rural communities, additional primary care providers also significantly decreased amputations per 100,000 residents (mean difference = −0.12, 95% confidence interval: −0.23, −0.0008).

Conclusions: Policy-driven strategic health care resource allocation at the local level may benefit patients in high-need, low-resource areas and promote a reduction in amputations.

Introduction

Similar to many other states and the nation in aggregate, nontraumatic lower extremity amputation rates in Texas are high, particularly among those categorized as black or Hispanic.[1] Although a combination of atherosclerotic risk factors and limited access to health care may partly explain these increased amputation rates, Hispanic ethnicity and black race are consistently independently associated with amputations.[2,3] Compared with non-Hispanic white patients, racial minorities are more likely to undergo primary, repeat, and above-knee amputations and are less likely to undergo limb-saving revascularization and angioplasty.[4-8] Although health inequalities have become a more public concern and greater resources have been dedicated to improving health care delivery, racial

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disparities continue to persist and significantly affect health outcomes.

Targeted interventions aimed at reducing racial health disparities among at-risk populations may be more effective than general public awareness campaigns or other unfocused efforts. Studies show that patient-level interventions that are interpersonal and culturally tailored are effective in improving diabetes care and interrupting the pathway to amputation.[9-11] In particular, targeted interventions result in even greater benefit to patients living in high-need, low-resource areas and help reduce gaps in care.[12] Provider-level interventions have demonstrated an improvement in African American patients' glycemic control such that it was comparable to those seen in diabetes specialty clinics.[13] The improved health outcomes we see due to successful and focused patient, provider, and health care interventions can help inform public health policy that is directed toward reducing racial health disparities.

Herein, we describe our analysis of Texas counties and Houston zip codes to determine if amputation rates are associated with community-level characteristics and resource utilization. We aimed to identify factors that may be specifically targeted through practice and health policy to improve amputation rates.

Methods

To identify factors associated with the increased total amputation rates by geographic location, we collated data from four sources for our analysis—Texas Inpatient Public Use Data File, Health Resources and Services Administration, County Health Rankings and Roadmaps, and the Houston Area Survey (HAS). To provide a comprehensive view of factors describing amputation disparities, we conducted the analysis on two geographic levels: the county level in Texas and the zip code level in the greater Houston metropolitan area. All the data sets used in this study were publicly available. The HAS data are available to the public on request from the Kinder Institute for Urban Research at Rice University. Given the publicly available nature of these data sets, this study is not considered human subjects research and was therefore exempt from review by an Institutional Review Board.

Texas county-level data

The Texas Inpatient Public Use Data File is provided by the Texas Department of State Health Services. Patient zip codes and Federal Information Processing Standards county codes were used to link outcomes to regions. The Health Resources and Services Administration and the Robert Wood Johnson Foundations' County Health Rankings and Roadmaps provided descriptive data on health care resources and characteristics (Fig. 1).

Houston area zip code–level data

The Kinder Houston Area Survey is administered, collected, and managed by Rice University's Kinder Institute for Urban

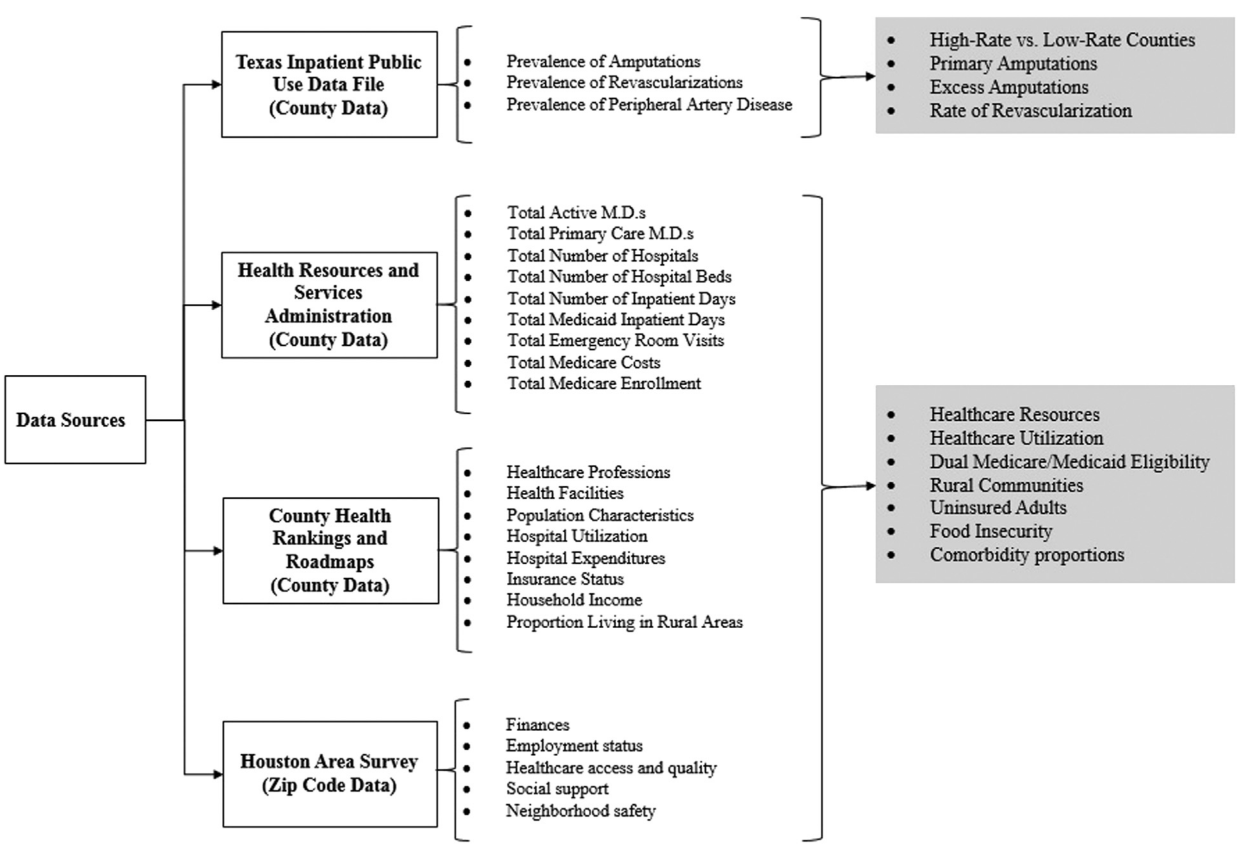

Fig. 1 – Data map of variable sources and summary of relevant variables.

Research.[14] Systematically random samples of responses from Harris County and the greater Houston area provide information on demographics and regional characteristics within zip codes. Response rates to the survey during the periods of interest were estimated at 75%.[15] The zip codes used from the Kinder Houston Area Survey were the residential zip codes of individuals responding to the survey.

Outcome measures

The primary outcome measure was the number of total nontraumatic major lower extremity amputations proximal to the ankle, in each Texas county. We also defined binary variables identifying high-rate counties and zip codes as regions that reported population-weighted amputation rates in the highest 25%. Excess amputations were defined as the number of additional amputations among people categorized as black or Hispanic when compared with Caucasians. Taken together, models generated using these dependent variables were used to highlight high-rate areas for amputations and associated factors in a geographic region. Furthermore, the number of amputations weighted by population was also modeled as a continuous variable.

Statistical analysis

Categorical data were described using counts and proportions. Medians and interquartile ranges (IQRs) were used to describe continuous variables that were not normally distributed. Linear and logistic regressions were used to identify health care resource and patient-level factors that could explain increasing amputations throughout Texas counties and zip codes in the greater Houston area. Variables that were relevant based on existing literature and statistically significant at a P-value of <0.10 were included in the models in a stepwise fashion. To remain in the final model, all variables were significant at a $P < 0.05$. Final models were adjusted for the population size in each county or zip code. Intercooled Stata, version 13 (StataCorp, College Station, TX), was used for all statistical analysis.

Results

Amputations and amputation rates among Texas counties

Our analysis includes demographic and health care resource availability data from all 254 counties in Texas during the 5-year period between 2005 and 2009 (Table 1). We identified 33 counties (13%) in Texas as high-rate amputation areas (Fig. 2A). Across all Texas counties, the median number of amputations was 5.6 per 100,000 residents. The top four most densely populated, high-rate amputation counties were the Starr, Cherokee, Jim Wells, and Grimes counties (Table A1). Despite some populous cities such as Rio Grande (population = 14,518) and Jacksonville (population = 14,910), most of the largest cities in high-rate amputation counties have relatively small populations, ranging between 1000 and 5000 residents (16/33, 48%). Low-rate amputation counties had a median of 4.5 lower extremity amputations per 100,000 residents, whereas high-rate amputation counties had a median of 14.4 per 100,000 residents. The median number of primary amputations (defined as amputations in the absence of previous revascularizations) in low-rate counties was 4.3 per 100,000 residents (IQR: 1.9-7.2) compared with 13.9 (IQR: 11.3-19.4, $P < 0.001$) in counties with high amputation rates.

In unadjusted comparisons (Table 1), high-rate amputation counties had significantly fewer available health care resources (including fewer primary care providers [Fig. 2B] and total hospitals) and lower health care utilization (fewer total number of Medicaid inpatient days). Areas with high amputation rates also had fewer total medical doctors serving the county than the low-rate cohort (37 *versus* 93, respectively, $P < 0.05$). In addition, a reduction in health care resources was further observed through a significantly lower median number of full-time hospital personnel in counties with high amputation rates (79 *versus* 162, $P < 0.05$).

Factors associated with amputations in adjusted models

Dual Medicare/Medicaid eligibility and emergency room (ER) visits for foot complications were each associated with more amputations (Table 2). However, as the number of ER visits for foot complications increases, greater dual eligibility was associated with decreased total amputations. Where rural communities made up more than 70% of the county, fewer amputations were associated with every additional primary care provider per 100,000 residents (mean difference = −0.004, 95% CI = −0.007, −0.0005).

Risk of excess amputation in high-rate counties was higher among residents with diabetes (odds ratio [OR] = 1.5, 95% CI: 1.2, 1.8) and people categorized as black (OR = 1.1, 95% CI: 1.0, 1.2; illustrated by Fig. 2C). Specifically, excess amputations among people categorized as black were associated with increasing reports of uninsured adults, food insecurities, and the total number of active physicians (Table 3).

The median number of revascularizations across Texas counties was 25.0 per 100,000 (Fig. 2D). When adjusted for diabetes prevalence, limb-saving revascularizations occurred more frequently with (1) more ER visits for foot complications (mean difference = 0.9, 95% CI: 0.8, 1.0) and (2) increasing proportions of individuals older than 65 years (mean difference = 0.4, 95% CI: 0.2, 0.7). However, no association was found between limb-saving revascularizations and Medicare eligibility or enrollment.

Amputations and amputation rates in the greater houston metropolitan area

Census-weighted survey data and amputation information were available on 242 zip codes across the greater Houston metropolitan area. Median reports of poor health care, lack of safety, retirees, people characterized as black, and Hispanic were higher among zip codes with high amputation rates ($n = 61$) compared with low-rate zip codes ($n = 181$). In unadjusted, univariable comparisons, neighborhoods in zip codes with high amputation rates reported a higher percentage of insurance enrollment. This association was not observed in the adjusted model.

Table 1 – Participant characteristics and health care resource availability among Texas counties comparing areas with low *versus* high amputation rates.

Variable	Low rate counties*, median (IQR)	High rate counties*, median (IQR)	P value
County demographics			
Female (%)	50.3 (48.9-50.8)	50.1 (48.4-50.8)	0.576
Race/ethnicity			
Caucasian (%)	60.7 (43.3-73.8)	59.8 (48.8-73.1)	0.576
African American (%)	3.9 (1.4-9.1)	3.6 (0.9-8.5)	0.852
Hispanic (%)	26.7 (17.9-48.9)	22.8 (17.1-47.7)	0.576
Native American (%)	1.1 (0.9-1.4)	0.9 (0.8-1.4)	**0.040**
Asian (%)	0.7 (0.5-1.1)	0.6 (0.4-0.7)	**0.015**
Participants living in rural areas (%)	49.9 (23.5-77.6)	73.5 (56.7-100)	**0.002**
Uninsured participants (%)	30.0 (27.3-33.4)	30.7 (27.6-32.5)	0.351
Diabetes (%)	11.8 (10.6-13.0)	12.1 (10.8-13.3)	**< 0.001**
Health care costs ($)	10,597.3 (9686.2-11,349.9)	10,736.2 (9921-11,718.3)	0.256
Quality of life (rank)	118 (58-173)	186 (74-223.5)	0.219
Health care resource availability			
Number of primary care providers per 10,000 residents	36 (8-158)	13 (0-34)	**0.017**
Active MDs†	89 (26-395)	33 (4-76)	**0.015**
Number of MDs†	93 (30-427)	37 (5-100)	**0.005**
Number of general practice MDs	14 (5-37)	5 (0-16)	**0.020**
Number of family medicine MDs	12 (3-33)	4 (0-14)	**0.020**
Number of hospitals†	3 (3-6)	3 (0-3)	**0.027**
Number of full-time hospital personnel†	162 (35-389)	79 (0-155)	**0.017**
Number of rural health clinics	6 (0-12)	6 (0-11)	0.210
Number of emergency room visits in 2005	2345 (0-8526)	2025 (0-6470)	0.852
Number of inpatient days†	4063 (0-15,661)	4070 (0-14,409)	0.852
Number of medicare inpatient days†	5161 (0-18,709)	3165 (0-10,411)	0.351
Number of medicaid inpatient days†	1152 (20-5528)	168 (0-1410)	**0.040**
Number of people enrolled in medicare†	10,006 (3679-24,377)	7051 (3180-13,107)	0.191
Number of people eligible for both medicaid and medicare†	3389 (1114-7994)	3224 (1047-4162)	0.576
Median household income (mean, SD)	22,027.53 (42,452.98)	52,774.79 (62,289.65)	**0.003**
Number of people in poverty	16,427 (4031-39,958)	12,734 (5924-20,066)	0.191
Total deaths	1029 (316-2790)	635 (207-1080)	**0.005**

Values in bold indicate statistical significance at P-value <0.05

* Low-rate counties are defined as Texas counties with more than 11 leg amputations per 100,000 patients per year, whereas high-rate counties are those with more than 11 leg amputations per 100,000 residents per year.

† In total.

When examining the total number of lower extremity amputations in each zip code, we found that increasing numbers of amputations were associated with neighborhoods that reported greater safety issues. High-rate amputation areas were characterized by a greater proportion of people categorized as black (OR: 1.06, 95% CI: 1.02, 1.10), Hispanics (OR: 1.07, 95% CI: 1.03, 1.12), and retired individuals (OR: 1.01, 95% CI: 1.00, 1.02).

Discussion

The purpose of this study, which examined Texas county-level and zip code–level data from 2005 to 2009, was to determine how socioeconomic status (SES) and health care resource distribution affect nontraumatic lower extremity amputation rates across Texas. Our results at the county level indicate that increased amputations were associated with increasing dual Medicare/Medicaid eligibility and increasing number of ER visits for foot complications. Individuals with a history of diabetes and who were categorized as black were more likely to live in high-amputation-rate counties. When compared to individuals categorized as white or Caucasian and among individuals categorized as black who received amputations, risk factors include uninsured status, reports of food insecurities, and increasing number of active physicians in the area. Older individuals and increased ER visits for foot complications were more likely to receive revascularizations when compared with those who did not receive revascularizations.

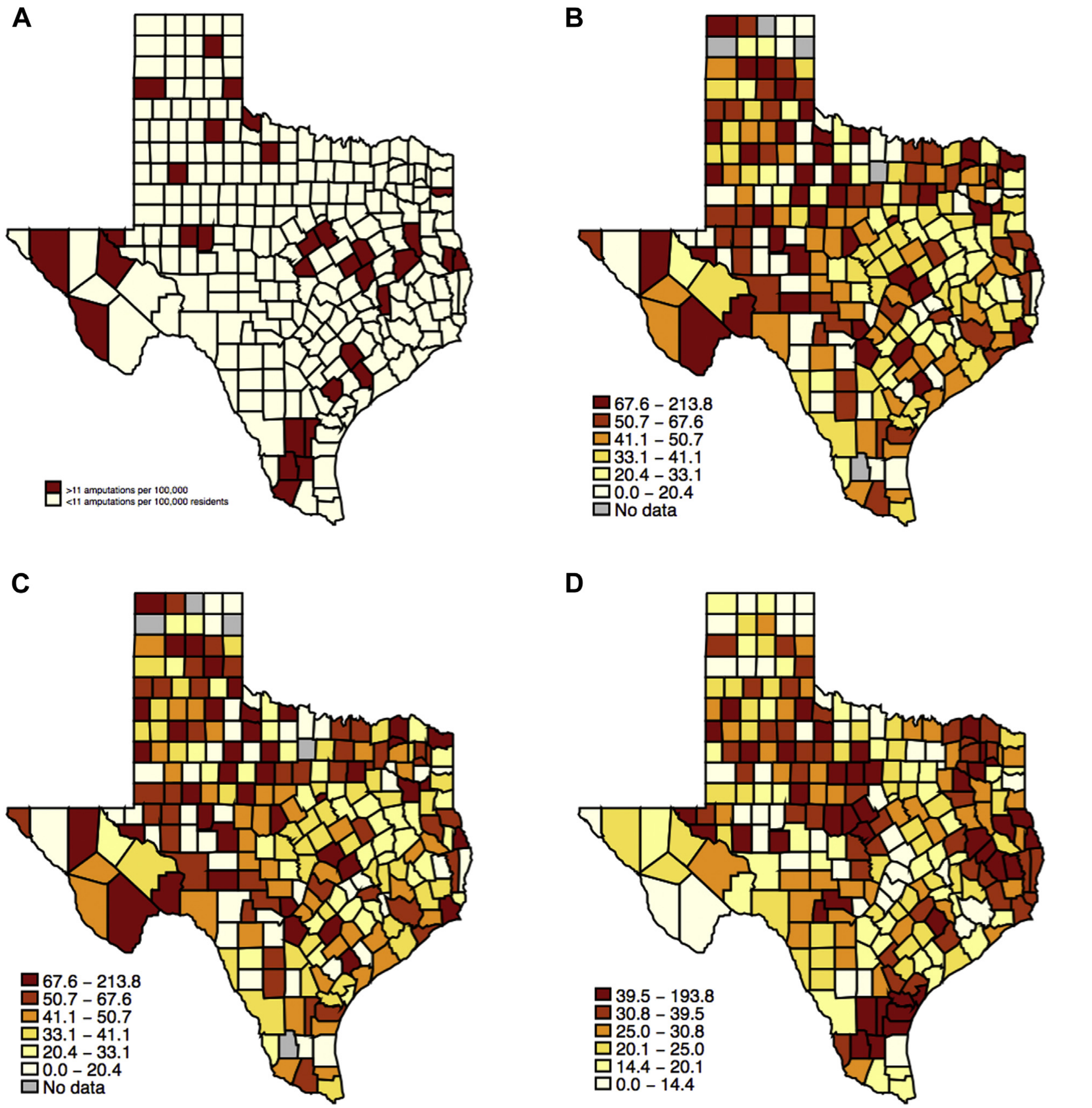

Fig. 2 – Distribution of amputations, health care resources, and revascularization attempts across Texas. (A) Geographic distribution of high- *versus* low-rate amputation counties; (B) Number of primary care providers per 100,000 residents. (C) Geographic distribution of counties with excess amputations among people categorized as black compared to white/ Caucasian. (D) Number of revascularizations per 100,000 residents. (Color version of figure is available online.)

Similar to previous studies, we found that African American race, diabetes, and rural counties were associated with higher amputation rates.[16,17] Counties with high rates of leg amputations had fewer available health care resources and lower utilization of these resources. Interestingly, factors such as the number of rural primary care providers were found to mitigate the rate of amputation. We also noted that amputations were not associated with revascularizations at the county level. Although this finding was also reported by Goodney *et al.*,[18] our study emphasizes similar discrepancies in treatment practices at the local level.

We found that dual Medicare/Medicaid eligibility is associated with increased amputations. Considering that Medicare covers the elderly and Medicaid generally covers those in low-income brackets, this catchment population itself may account for the increased risk of amputation that is associated with dual eligibility. Other studies on Medicare, Medicaid, and lower extremity amputation have described similar results.[19,20] In the setting of acute care, dual insurance eligibility was associated with fewer major amputations. One point of current consideration, however, is that owing to Texas' decision to not participate in the recent Medicaid expansion, the

Table 2 – Factors associated with increasing total amputations and total amputations weighted by population in high-rate Texas counties.

Variable	Mean difference	95% confidence interval	*P* value
Dependent variable: total amputations			
Number of people eligible for dual medicare & medicaid	0.0006	(0.0004, 0.0008)	<0.001
Number of people with limited access to healthy foods	0.001	(0.0010, 0.0013)	<0.001
Number of people categorized as black	0.0002	(0.0001, 0.0003)	<0.001
Number of ER visits for foot complications	0.194	(0.16, 0.23)	<0.001
Interaction between ER comps. visits and medicare/Medicaid*	-1.21×10^{-06}	(-1.52×10^{-06}, -8.96×10^{-07})	<0.001
Dependent variable: total amputations weighted by population			
County rank of health behaviors	0.10	(0.04, 0.17)	0.002
Rate of primary care providers	0.15	(−0.09, 0.39)	0.229
Health care costs	0.005	(0.002, 0.007)	0.001
% Diabetes	7.97	(4.56, 11.37)	<0.001
Physical distress	−5.54	(−9.71, −1.37)	0.009
% of people considered rural	0.13	(−0.08, 0.33)	0.232
Interaction between PCP rate and rural†	−0.004	(−0.007, −0.0005)	0.022

comps. = complications; PCP = primary care provider.

* For every one-unit increase in ER visits for foot complications at increasing dual Medicare/Medicaid prevalence, the total number of amputations decreased.

† For every one-unit increase in PCP rate at the 70%, 80%, and 90% rural community levels, amputations decrease.

population eligible for dual insurance enrollment is relatively small compared with other states, ranking 16th in the nation.[21]

Counties with higher-than-expected amputation rates are more likely to be rural and with larger proportions of the population classified as diabetic and black. This is similar to McGinigle's finding that medically underserved counties in North Carolina had increased odds of undergoing limb amputation.[22] Although rural counties reported increased total amputations, we found that rural counties reported fewer ER visits. Although our data set does not allow us to track patients' progressive care or directly assess the effect of hospital distance, this finding suggests that patients in rural counties may be traveling to urban counties for care, potentially explaining the increase in amputations.

In the Houston area zip code–level analysis, the heterogeneous nature of metropolitan communities may explain the variation in our findings when compared with the county-level analysis. Given the zoning norms in the greater Houston area, the amalgamation of diverse communities could explain the absence of definitive SES and neighborhood factors that describe amputation rates. The increased odds of high-rate zip codes being African American reflect similar racial risk factors seen at the county level. Our findings, juxtaposing county and city level factors, caution against relying only on traditional explanations for amputation rates (i.e., SES, insurance status) that overlook geographical and cultural structures. Comparison of county-level and zip code–level data shows that although there are factors that are consistently associated with increasing amputations at the county level, these factors may not describe amputation rates at a local level.

The primary strength of this study lies in our description of amputation rates as they relate to health care resource distribution in the state of Texas. We provided macroscopic results at the countywide level while also comparing findings to local, citywide data. We acknowledge that utilizing secondary data sets for our analysis, which is inherently susceptible to errors in coding and sampling, is a limitation. Other limitations include our inability to assess resource use, describe treatment algorithms, robustly adjust for disease severity, and provide granularity with respect to SES. Facility-level detail would also provide some insight into the associations between ER visits for foot complications, amputations, and revascularizations. In addition, some variables analyzed on the county level were unavailable in the Houston zip code–level data set, limiting our direct comparison between statewide and citywide trends.

Despite advances in medical care and technology, PAD-related amputation rates are on the rise across Texas.[23] However, our findings make us hopeful that focused interventions

Table 3 – Factors associated with excess amputations among people categorized as black.

Variable	Mean difference	95% confidence interval	*P* value
Number of uninsured adults	0.0002	(0.0002, 0.00024)	<0.001
Number of people with limited access to healthy foods	−0.0002	(−0.0002, −0.0001)	<0.001
% of people with food insecurity	0.228	(0.14, 0.32)	<0.001
Total number of active MDs	0.0007	(0.0005, 0.0009)	<0.001

and health policies that account for regional factors can blunt the rate of rise. Specifically, health policy can be informed by the association of dual Medicare/Medicaid eligibility in ER visits for foot complications and the added benefit of increasing the number of primary care providers in rural counties. Although our study contributes to the literature on the associations between health care distribution and nontraumatic lower extremity amputations, we recognize the limitations of the study design and realize that our findings represent non-causal statistical associations. As causality cannot be assessed from this study, further research is needed to determine if similar trends in Texas are seen elsewhere in the United States and to propose effective interventions and policy to address modifiable risk factors at a local, community level.

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Disclosure

The authors report no proprietary or commercial interest in any product mentioned or concept discussed in this article.

Supplementary data

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