Risk of Ipsilateral Reamputation Following an Incident Toe Amputation Among U.S. Military Veterans With Diabetes, 2005–2016

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OBJECTIVE

To assess whether the risk of subsequent lower-limb amputations and death following an initial toe amputation among individuals with diabetes has changed over time and varies by demographic characteristics and geographic region.

RESEARCH DESIGN AND METHODS

Using Veterans Health Administration (VHA) electronic medical records from 1 October 2004 to 30 September 2016, we determined risk of subsequent ipsilateral minor and major amputation within 1 year after an initial toe/ray amputation among veterans with diabetes. To assess changes in the annual rate of subsequent amputation over time, we estimated age-adjusted incidence of minor and major subsequent ipsilateral amputation for each year, separately for African Americans (AAs) and whites. Geographic variation was assessed across VHA markets ($n = 89$) using log-linear Poisson regression models adjusting for age and ethnoracial category.

RESULTS

Among 17,786 individuals who had an initial toe amputation, 34% had another amputation on the same limb within 1 year, including 10% who had a major ipsilateral amputation. Median time to subsequent ipsilateral amputation (minor or major) was 36 days. One-year risk of subsequent major amputation decreased over time, but risk of subsequent minor amputation did not. Risk of subsequent major ipsilateral amputation was higher in AAs than whites. After adjusting for age and ethnoracial category, 1-year risk of major subsequent amputation varied fivefold across VHA markets.

CONCLUSIONS

Nearly one-third of individuals require reamputation following an initial toe amputation, although risks of subsequent major ipsilateral amputation have decreased over time. Nevertheless, risks remain particularly high for AAs and vary substantially geographically.

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Incidence of lower-extremity amputation (LEA) among people with diabetes in the U.S. declined substantially since the 1980s and the mid to late 2000s. Recent data have indicated that diabetes-related LEA increased between 2009 and 2015, driven by a 62% increase in the rate of toe and partial foot amputations (minor amputations) (1). Although the reasons for the increase have not yet been determined, the authors hypothesized that it may be due to a shift in clinical decision making by treating complications that used to be treated with a major amputation with a minor amputation instead. The rates of minor amputations tend to be about twice as high as the rates of major LEA (1–3); amputations of the toe are the most common level of minor LEA (4). Although toe amputations are often considered to be minor operations, they are costly: the median total direct cost for a toe amputation in the Veterans Health Administration (VHA) in 2012 was $30,636 (5). Moreover, the costs are not just financial. Attempts to heal toe amputations often require that patients avoid bearing weight, thereby reducing mobility, which negatively impacts both independence and quality of life (6). Removal of the toe may cause or exacerbate foot deformities, resulting in "hot spots" that are more vulnerable to injury and infection. There is evidence that the toe amputated makes a difference; amputation of the first (hallux) toe is associated with an increased risk of foot deformities (7) and results in greater peak pressures (8,9), factors that may make the foot more susceptible to ulceration and reamputation.

Historical data indicate that individuals with a toe amputation are at high risk of a subsequent amputation. Dillingham et al. (10) estimated that >37% of patients with diabetes who had a toe amputation in 1996 had a second LEA within 12 months, proportions that exceeded reamputation rates following a transtibial (25%) or a transfemoral (18%) amputation. Although there are more than a dozen studies that have assessed risks of subsequent amputations among patients who underwent toe or ray (a more extensive toe amputation that involves excision of the metatarsal head) amputation(s) (10–23), most prior studies were small; only four studies included >200 patients (10,15,20,22), and of these, the one by Dillingham et al. (10) was the largest with 889 U.S. Medicare beneficiaries. One important limitation of this study was the inability to distinguish subsequent amputations on the ipsilateral limb from amputations on the contralateral limb because information on laterality was not available. Ascertaining laterality is critical to understanding whether the index toe amputation failed to heal (as inferred by an ipsilateral LEA) or whether the patient developed a new problem that resulted in an amputation (as inferred by a contralateral LEA). Furthermore, the Dillingham et al. study was conducted >20 years ago, used a single year of data, and only included those 65 years of age and older. Contemporary data, including a broader age spectrum of patients, are needed to understand current risks.

Previous studies have shown that the incidence of LEA among those with diabetes varies substantially across geographic regions (24–29) and by ethnoracial categories (27–29), although no studies, to our knowledge, have evaluated geographic or ethnoracial variation in subsequent amputations among individuals after an initial toe amputation. Among people with diabetes, African Americans (AAs) have LEA rates that are 1.5–4 times greater than whites (30–32). The factors underlying the racial variation have not been determined; socioeconomic factors, health care factors, health behaviors, or stresses associated with institutional and interpersonal racism may play a role. On a practical level, identifying geographic and ethnoracial variation is important because they may reveal clues about differences in management of foot ulcers, thresholds for performing an initial toe amputation, and secondary prevention efforts.

The Department of Veterans Affairs operates the largest integrated health care system in the U.S. with >9 million veteran enrollees (33), 24% of whom have diabetes (34). Since 1993, the VHA has offered a model of care to prevent or delay amputation through early identification of patients with limb loss (35). The VHA has electronic medical records permitting the study of large populations and can implement innovative models of care. Thus, much can be learned by comprehensively assessing the variation in risk of subsequent amputation following a toe amputation in this system. Our aim was to determine the extent to which the incidence of subsequent amputations and death following an initial toe amputation has changed over time and varies by geographic region and demographic characteristics. As a secondary aim, we also investigated variation in the likelihood of subsequent amputation by which toe (e.g., hallux vs. nonhallux) was amputated.

RESEARCH DESIGN AND METHODS

Data Sources

We used VHA national electronic medical record the Corporate Data Warehouse (CDW) to identify potentially eligible patients. The CDW includes information on demographics, diagnoses, procedures, medications, laboratory results, and health services usage.

To obtain information about amputations performed outside the VHA among veterans ≥65 years of age as well as information on ethnoracial category and comorbidities, we linked data from the CDW to the Centers for Medicare & Medicaid Services databases, including Medicare Part A (hospital insurance), Part B (medical insurance), and denominator files, which include enrollment information. We also considered for inclusion procedures that were done outside the VHA but paid for by VHA (fee basis).

Study Design, Population, and Inclusion/Exclusion Criteria

The key eligibility criteria for this longitudinal cohort study were diagnosis of diabetes and an initial toe or ray amputation (hereafter referred to simply as toe amputation) between 1 October 2004 (the start of fiscal year [FY] 2005) and 30 September 2016 (the end of FY2016) performed in VHA facilities or paid for by VHA. Diabetes was determined on the basis of having two or more ICD-9 codes for diabetes (250, 357.2, 362.0, and 366.41) (see Supplementary Table 1 for ICD-10 codes used in FY16) from inpatient or outpatient diagnoses on separate days in the 2 years before the initial toe amputation or one prescription for a hypoglycemic medication in the year before the initial toe amputation (36). Toe amputation was determined on the basis of having an ICD-9 inpatient or outpatient procedure code (84.11); a Current Procedural Terminology (CPT) code (28810, 28820, or 28825); or for FY16, 1 of 60 ICD-10 procedure

codes (see Supplementary Table 2). To ensure that it was the first amputation for an individual, we reviewed each patient's medical records for diagnosis and/or procedure codes indicating a prior amputation for the 5 years before the first toe amputation. Using FY2016 data (the only study year in which ICD-10 data were available), we determined whether the initial toe amputated was a hallux toe (ICD-10 codes 0Y6P0Z0–3 or 0Y6Q0Z0–3) versus any other toe. We excluded patients who at baseline had all toes removed (e.g., transmetatarsal amputation) or a bilateral amputation (amputations of toes on both feet) and those whose initial toe amputation laterality could not be determined.

Outcomes of Interest

The primary outcome was a subsequent ipsilateral minor or major LEA in the 12 months after the initial toe amputation. A secondary outcome was subsequent contralateral LEA. We defined minor amputations as a toe, ray, or transmetatarsal amputation. Major amputations included an amputation at or more proximal to the ankle, including Syme amputation; ankle, knee, or hip disarticulation; and transtibial or transfemoral amputations. We also assessed death in the 12 months after the initial toe amputation because it would preclude an individual from having a subsequent amputation as well as reduce their time at risk for a subsequent amputation.

Laterality of initial and any subsequent LEAs was determined on the basis of a combination of ICD-10 codes, CPT modifier codes (RT; LT; T9 for right foot, fifth digit, etc., which are added to the CPT code with a hyphen), and natural language processing. Neither CPT laterality modifiers nor ICD-10 codes were available for 4,965 amputation procedures. Details on methods used for natural language processing are available in Supplementary File 1. In natural language processing, the quality of a classifier is determined on the basis of precision (similar to the positive predictive value), defined in this study as the fraction of procedures classified as being performed on the right foot that were truly done on the right foot (and likewise for procedures done on the left foot and classified as being done on the left foot). The precision of the classifier developed for this study was at least 0.88, depending on the group (see Supplementary File 1 for details). There were 214 individuals for whom there were multiple documents related to the amputation, and one-half indicated left, and one-half indicated right. One author (A.J.L.) reviewed these records, and in 70 of the 214, we determined the laterality and confirmed that the procedure was not a transmetatarsal amputation. We either were unable to determine the laterality or determined that the procedure did not meet inclusion criteria in the remaining 144 procedures.

Covariates

The demographic covariates that we examined were age ($<$55, 55–64, 65–74, 75–84, $\geq$85 years), sex (male, female), ethnoracial category (American Indian/Alaska Native [AI/AN], Asian/Pacific Islander, AA, white, other), Hispanic/Latino (yes, no), and marital status (married, separated/divorced, widowed, single). Upon enrollment in VHA, veterans are assigned to one of eight priority groups, which are determined on the basis of military service history, disability rating, income level, Medicaid eligibility, and other criteria. We used VHA priority group as a proxy for low-income and disability status using the approach developed by other researchers (37) as follows: copayments required (priority groups 7 and 8), low income (priority group 5), moderate disability (priority groups 2, 3, and 6), and severe disability (priority groups 1 and 4). We used the Gagne comorbidity index to classify patients into one of four categories ($<$0, 1–2, 3–4, $>$4); a higher number indicates a greater burden of comorbidities (38). We also assessed VHA region (Continental, Midwest, North Atlantic, Pacific, Southeast) on the basis of the facility where the initial toe amputation surgery was performed. Rurality (on the basis of the patients' current address) was determined according to Rural Urban Commuting Area (RUCA) and categorized as follows: urban (RUCA 1.0 or 1.1), highly rural (RUCA 10.0), and rural (all other RUCA values) (39–41). We assessed geographic variation using VHA markets that are nested within the 18 geographically divided administrative areas called Veterans Integrated Service Networks (42). Patients were assigned to the market where their initial toe amputation was performed. For some patients, we were only able to determine that their initial amputation had occurred within one of several VA markets, but not the specific market in which it had occurred. Consequently, 10 of the initial 96 VA markets were combined into 3 larger markets, resulting in 89 markets included in analyses.

Statistical Analyses

We first calculated the percentage of individuals who had a subsequent ipsilateral minor or major amputation, died, or survived without subsequent ipsilateral LEA in the 12 months after initial amputation overall and by demographic (e.g., age, sex, ethnoracial category, marital status, enrollment priority), health (e.g., medical comorbidities), and geographic (VHA region and rurality) characteristics.

To assess changes in the annual rate of subsequent LEA between FY2005 and FY2016, we estimated age-adjusted incidence of minor and major subsequent ipsilateral LEA for each year, separately for AAs and whites, the two most common races, making up 96% of the cohort. We used FY2015 data as the reference population to control for differences in the distribution of ages across years. We accounted for the reduced follow-up time among those who died by only including in the denominator the fraction of the year (e.g., days between initial toe amputation and death divided by 365) that they were alive and could undergo a subsequent LEA. To quantitatively assess linear trends in subsequent ipsilateral LEA over time, we fit a log-linear Poisson regression model for each ethnoracial group (AAs and whites) for both minor and major LEA. Variables included in each model were days since initial toe amputation and categories of age. The follow-up time was used as an offset in the Poisson regression models to account for differential observation times as a result of death. For tests of linear trend, data from FY2016 were excluded because of concerns about noncomparability of data as a result of the change in codes from ICD-9 to ICD-10.

To assess how the risk of subsequent ipsilateral LEA varied by month within the year following the initial toe amputation, we divided the year into 12 30-day intervals and calculated the risk of subsequent ipsilateral amputation in each 30-day period among AAs and whites. Individuals who were alive and had not

had a subsequent ipsilateral LEA at the beginning of the 30-day interval were included in the denominator; the numerator included individuals who had their first ipsilateral LEA within the 30-day interval.

To assess geographic variation in risk of subsequent ipsilateral LEA, we fit log-linear Poisson regression models with fixed effects for age and race and a random intercept for market where the index toe amputation was performed. An offset was added to the models following the same method as detailed above. To test for spatial autocorrelation, we used Moran I test (43). More details can be found in Supplementary File 3.

Finally, as a secondary analysis, using data from FY16, we calculated the percentage of individuals who had a subsequent ipsilateral minor or major amputation, died, or survived without subsequent ipsilateral LEA in the 12 months after initial amputation among those whose initial toe amputation involved the hallux compared with those who had other toes amputated. We also described demographic (e.g., age, sex, ethnoracial category, marital status, enrollment priority) and health (e.g., medical comorbidities) characteristics in these two groups. Using data from all years, we also calculated the percentage of patients who had a subsequent minor or major contralateral amputation on the basis of whether they had a subsequent ipsilateral amputation or died.

RESULTS

Between FY2005 and FY2016, 32,132 veterans had a toe amputation in a VHA facility or paid for by VHA. Of these, 14,214 did not meet inclusion criteria because they did not have a diagnosis of diabetes (n = 7,126), had a prior amputation (n = 6,650), had a transmetatarsal amputation at baseline (n = 92), or had bilateral amputations at baseline (n = 346). In addition, laterality could not be determined in 132 patients, leaving 17,786 individuals for analysis. In the 12 months after their initial toe amputation, 10.2% had a subsequent major ipsilateral LEA (with or without a subsequent minor ipsilateral amputation), 23.9% had a subsequent minor ipsilateral LEA (without having a major amputation), 58.3% had no subsequent ipsilateral LEA and were alive at the end of 12 months, and 7.6% died without having a subsequent ipsilateral LEA (Table 1). Note that 464 (2.6%) of patients had a minor LEA and died within 1 year of their initial amputation and that 356 (2.0%) had a major amputation and died within 1 year of their initial amputation such that 1-year cumulative mortality was 12.2%.

Table 1 also shows the distribution of demographic, health, and geographic characteristics by outcomes. Because the sample size was large and all comparisons were statistically significant at $P < 0.01$, we did not rely on statistical significance to indicate an important difference. Instead, we considered differences in characteristics across the categories of outcomes of at least 3 percentage points as meaningful. Risk of subsequent major ipsilateral LEA was greater among older versus younger individuals, men versus women, AI/ANs and AAs compared with white, Hispanic/Latinos versus non-Hispanic/Latinos, those with more comorbidities, and those living in the Southeast versus Midwest or Pacific regions. One-year amputation-free survival was greater among those who were younger, female, white, non-Hispanic/Latino, and unmarried versus widowed; with a moderate disability versus severe disability; who had fewer comorbidities; and who lived in the Midwest or in a rural or highly rural area versus an urban area.

One-year risk of subsequent major LEA (Fig. 1, solid line) decreased between 2005 and 2015 (from 0.116 to 0.064 in whites and from 0.202 to 0.135 in AAs, $P < 0.001$ for both categories) (Fig. 1). Reductions in risk were similar among whites and AAs ($P = 0.82$ for ethnoracial category $\times$ time interaction). Consequently, risks of major amputation remained substantially greater among AAs than whites. One-year risk of subsequent minor LEA did not change between FY2005 and FY2015 overall ($P = 0.44$); the time trend also did not differ across ethnoracial categories ($P = 0.75$ for ethnoracial group $\times$ time interaction).

For both AAs and whites, rates of subsequent ipsilateral LEA were highest in the 90 days after the initial toe amputation (Fig. 2). Rates in the first 30 days were substantially higher among AAs (202 subsequent ipsilateral LEAs per 1,000 patients) than whites (148 subsequent ipsilateral LEAs per 1,000 patients). The differences narrowed, but rates remained greater in AAs than whites in the 31–90 days after the initial amputation. Rates in the 91–365 days after initial amputation gradually decreased and were similar between the two groups.

Figure 3 displays the estimated 1-year risk of subsequent ipsilateral LEA for white patients between 55 and 64 years old (the most common ethnoracial and age category). There was not a significant interaction between age or ethnoracial category and market. After adjusting for age and ethnoracial category, there was 1.4-fold variation in 1-year risk of subsequent ipsilateral LEA (major or minor) across VHA markets and 5-fold variation in 1-year risk of subsequent major ipsilateral LEA. Risks for subsequent LEA (minor or major, Fig. 3*A*) were greatest in VHA markets located in southern Washington State, Oregon, California, Texas, and Florida; additional markets with high rates were located in New Jersey, New York, the District of Columbia, Mississippi, Ohio, Kentucky, and West Virginia. Nearly all the markets in the top quartile of risk for subsequent major LEA (Fig. 3*B*) were in the southeast. Moran I statistic indicated the presence of spatial autocorrelation for risk of subsequent major or minor ipsilateral LEA ($P = 0.015$) and subsequent major LEA ($P = 0.010$), indicating that risks in neighboring markets were more similar than markets that did not neighbor one another.

On the basis of FY2016 data (when ICD-10 codes first came into use), 39% (n = 772 of 2,005) of initial toe amputations involved the hallux (Supplementary Table 3). Risk of 1-year subsequent ipsilateral LEA was significantly greater among those who had a hallux removed (42.1%) compared with other toes (31.6%). The mean time to subsequent LEA was longer in those who had a hallux removed. Among those who had a subsequent ipsilateral amputation, ~53% of those who had a hallux removed had an amputation >30 days after their initial amputation compared with 46% of those who had a different toe amputated. Additionally, a greater proportion of those who had a hallux removed had a major LEA within 12 months (12.6% vs. 9.2%). There was little difference in the proportion who died among those who had a hallux compared with other toe amputated. There was also little difference by age, sex, and enrollment priority between

Table 1—Descriptive characteristics of VHA patients with diabetes with a toe/ray amputation and percentage who experienced an ipsilateral minor or major amputation, death, or neither in the 12 months after an initial toe amputation

Characteristic	Total, *n*	Subsequent major ipsilateral amputation* (*n* = 1,821)	Subsequent minor ipsilateral amputation* (*n* = 4,253)	No subsequent ipsilateral amputation and no death (*n* = 10,368)	Death and no subsequent ipsilateral amputation (*n* = 1,344)	χ^2 *P* value across 4 categories†
Total	17,786	10.2	23.9	58.3	7.6	
Age (years)						
<55	2,261	6.9	25.6	65.0	2.6	<0.001
55–64	7,183	9.9	25.0	59.9	5.2	
65–74	5,327	10.4	23.1	58.6	7.9	
75–84	2,389	13.4	21.9	50.7	14.1	
≥85	626	12.9	20.0	42.2	24.9	
Sex						
Female	261	6.5	23.0	66.3	4.2	<0.001
Male	17,525	10.3	23.9	58.2	7.6	
Race						
AI/AN	260	12.7	26.9	56.2	4.2	<0.001
Asian or Pacific Islander	209	10.0	24.4	56.0	9.6	
AA	3,480	15.9	23.7	53.8	6.5	
White	13,706	8.7	23.9	59.5	7.8	
Ethnicity						
Hispanic or Latino	1,117	13.4	24.9	55.1	6.5	<0.001
Not Hispanic or Latino	16,079	10.0	23.9	58.6	7.5	
Unknown	590	10.5	23.2	55.1	11.2	
Marital status						
Married	7,725	10.9	23.0	58.3	7.8	<0.001
Separated/divorced	6,082	9.8	24.9	58.3	6.9	
Widowed	1,878	11.2	23.4	55.1	10.3	
Single	2,086	8.2	25.0	61.0	5.8	
Enrollment priority						
Copayments required	2,084	9.0	23.9	60.6	6.5	<0.001
Low income	7,408	10.4	24.0	58.0	7.5	
Moderate disability	2,408	9.2	23.5	61.0	6.3	
Severe disability	5,841	10.9	24.0	56.7	8.5	
Gagne index						
≤0 (fewer comorbidities)	5,820	5.0	20.9	70.7	3.4	<0.001
1–2	5,617	10.7	25.3	59.0	5.0	
3–4	3,482	14.0	26.9	49.8	9.3	
>4 (more comorbidities)	2,867	15.4	23.6	42.0	18.9	
Region						
Continental	2,938	11.1	22.8	58.0	8.2	<0.001
Midwest	3,829	8.5	22.6	61.1	7.8	
North Atlantic	4,074	10.4	24.7	57.0	7.9	
Pacific	3,652	8.7	26.8	57.9	6.7	
Southeast	3,293	13.0	22.3	57.5	7.2	
Rurality						
Urban	11,912	10.3	24.9	57.1	7.6	<0.001
Rural	5,624	10.2	21.9	60.4	7.5	
Highly rural	224	8.0	18.3	67.4	6.2	

Data are % unless otherwise indicated. Numbers do not add up to totals because of missing data (i.e., *n* = 131 missing for race, *n* = 15 missing for marital status, *n* = 45 missing for enrollment priority, *n* = 26 missing for rurality). *Four hundred sixty-four (3%) patients had a minor amputation and died; 356 (2%) had a major amputation and died. †χ^2 tests only use data for patients with known values (e.g., those with missing race or ethnicity were excluded).

those who did and did not have a hallux amputation (Supplementary Table 4). A greater proportion of toe amputations in AAs were hallux amputations (25.4% vs. 17.8%). Those who had a toe other than the hallux removed were generally healthier, as measured by the comorbidity index.

Finally, ~1 in 12 people (*n* = 1,404, 7.9%) had a subsequent contralateral LEA in the year after their initial toe amputation. Risk of subsequent contralateral amputation was higher among those who had a subsequent major ipsilateral amputation (Supplementary Table 5).

CONCLUSIONS

Toe amputations have long been recognized as a harbinger of more dire outcomes, including additional forefoot and midfoot amputations, more proximal major amputations, and elevated mortality risk. Findings from our large, national study provide estimates of the

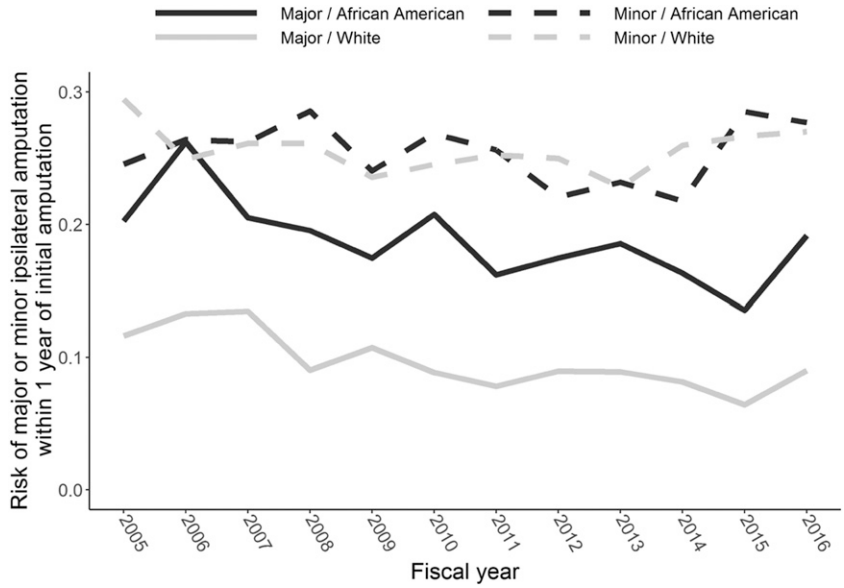

Figure 1—Age-adjusted time trends in rates of subsequent minor and major ipsilateral amputation in the 12 months following a toe/ray amputation in VHA patients with diabetes, FY2005–2016.

1-year risk of subsequent amputation and death in patients with diabetes who undergo a toe amputation. Regrettably, more than one-third of those who had an initial toe amputation required another amputation on the same foot or leg within 1 year, including 10% who had a major LEA. Furthermore, 12% of patients died within 1 year of the initial toe amputation, with or without having another LEA. Although 1-year risk of subsequent major LEA decreased between 2005 and 2015, ethnoracial disparities did not, and risks of subsequent minor LEA did not change (Fig. 1). Risks of a subsequent LEA were substantially greater among AAs than whites, especially in the first 30 days after the initial toe amputation (Fig. 2). The extensive geographic variation that we observed after controlling for age and ethnoracial differences suggests that practice patterns, for example, health care provider management decisions related to performing a toe amputation versus a more proximal amputation, may differ geographically. Furthermore, our findings of spatial autocorrelation (geographic clustering) indicate that individuals with a toe amputation living in neighboring markets were more similar in terms of their risks of subsequent ipsilateral amputation than individuals living elsewhere. Markets with high (or low) risks of subsequent ipsilateral amputation were surrounded by markets with similarly high (or low) rates. The areas we identified as having higher risks of subsequent ipsilateral amputation were generally not the same ones that Margolis et al. (25) identified. We are uncertain why results differ but note that the populations under study (veterans regardless of age with diabetes who had an initial toe amputation vs. Medicare beneficiaries with diabetes), time period (2005–2016 in our study vs. 2006–2008 in the study by Margolis et al.), and outcomes (subsequent ipsilateral LEA vs. incident minor and major LEA) differ between the two studies. Variation in revascularization procedures, for example, as has been seen in Texas (44), might also explain variation in subsequent amputation risk. Future studies are needed to understand the reasons for the variation.

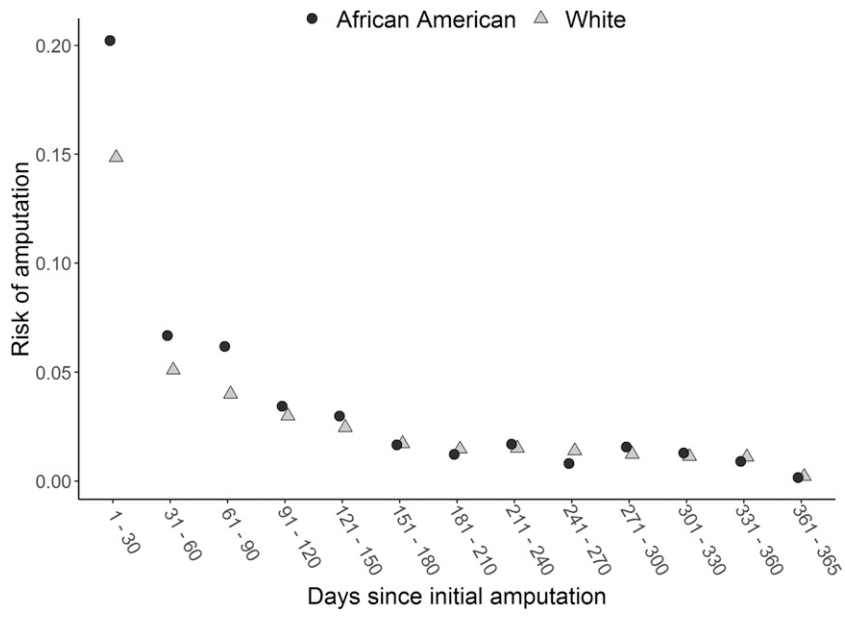

Figure 2—Incidence rate of subsequent ipsilateral amputation in the 12 months following a first toe/ray amputation, by time since amputation, separately for white and AA patients with diabetes. Analysis limited to AA and white patients (n = 17,186).

An important strength of our study is that we were able to determine whether amputations were performed on the ipsilateral or contralateral foot/leg by using procedure codes and natural language processing. In this way, we were better able to distinguish between amputations that failed to heal from amputations that occurred on the contralateral limb. Furthermore, by examining the timing of the first subsequent LEA, we were able to assess whether they occurred early or later in relation to the initial amputation. Finally, examination of risks by whether the toe amputated was a hallux provides evidence to support hypotheses related to the causes of the subsequent amputation. Nevertheless, while use of administrative data allowed us to include a large population, misclassification is a possibility because of omission of codes and incorrect entry of codes. For example, a relatively large fraction of individuals (18.7%) was excluded because these patients did not

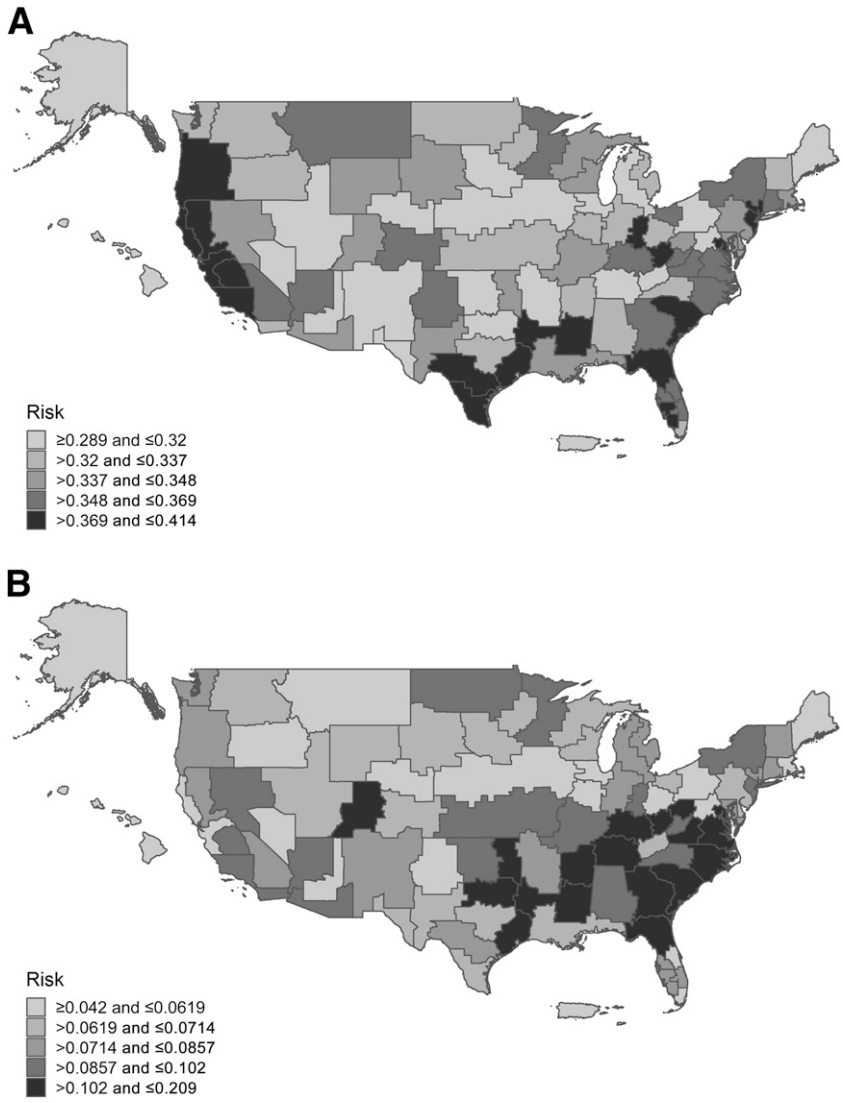

Figure 3—Twelve-month age- and race-adjusted risk of subsequent major or minor ipsilateral amputation (*A*) and major ipsilateral amputation (*B*) following an initial toe/ray amputation in patients with diabetes.

appear to have diabetes before their toe amputation. However, prior research demonstrated that the algorithm we used is highly sensitive (93%) and specific (98%), indicating that while we likely excluded some people who did have diabetes, because of the high sensitivity, we captured >90% (36). Also, we did not have information on the cause of the initial or subsequent LEA or information on healing or whether a subsequent amputation was planned (since codes alone cannot be used to make this determination). Furthermore, because veterans are not a random sample of the U.S. population, it will be important to evaluate how our findings generalize to nonveterans, ethnoracial minority groups not well represented in our study, and women.

In conclusion, on the basis of results from this national study, approximately one in three people who underwent a toe amputation required a subsequent amputation on the same foot within 1 year, often within the first 30 days. There was substantial variation in risk between AAs and whites and by market. To reduce the risk of reamputation in this population in the future, it will be critical to identify patients most likely to heal and clinical and patient practices/characteristics that can prevent subsequent amputations. Results from this large national sample provide precise estimates of the likelihood of a successful toe amputation, which will assist patients and providers in deciding on the best treatment for a diabetic foot complication involving these digits and can inform planning for program leadership at VHA and other health care institutions.

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