Declining Rates of Hospitalization for Nontraumatic Lower-Extremity Amputation in the Diabetic Population Aged 40 Years or Older: U.S., 1988–2008

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OBJECTIVE—To assess trends in rates of hospitalization for nontraumatic lower-extremity amputation (NLEA) in U.S. diabetic and nondiabetic populations and disparities in NLEA rates within the diabetic population.

RESEARCH DESIGN AND METHODS—We calculated NLEA hospitalization rates, by diabetes status, among persons aged ≥40 years on the basis of National Hospital Discharge Survey data on NLEA procedures and National Health Interview Survey data on diabetes prevalence. We used joinpoint regression to calculate the annual percentage change (APC) and to assess trends in rates from 1988 to 2008.

RESULTS—The age-adjusted NLEA discharge rate per 1,000 persons among those diagnosed with diabetes and aged ≥40 years decreased from 11.2 in 1996 to 3.9 in 2008 (APC −8.6%; $P < 0.01$), while rates among persons without diagnosed diabetes changed little. NLEA rates in the diabetic population decreased significantly from 1996 to 2008 in all demographic groups examined (all $P < 0.05$). Throughout the entire study period, rates of diabetes-related NLEA were higher among persons aged ≥75 years than among those who were younger, higher among men than women, and higher among blacks than whites.

CONCLUSIONS—From 1996 to 2008, NLEA discharge rates declined significantly in the U.S. diabetic population. Nevertheless, NLEA continues to be substantially higher in the diabetic population than in the nondiabetic population and disproportionately affects people aged ≥75 years, blacks, and men. Continued efforts are needed to decrease the prevalence of NLEA risk factors and to improve foot care among certain subgroups within the U.S. diabetic population that are at higher risk.

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Diabetes is a leading cause of nontraumatic lower-extremity amputations (NLEAs). Rates of NLEAs serve as an important gauge of the effectiveness of efforts to reduce diabetes complications because they are associated with numerous modifiable risk factors, including high blood pressure, high lipid and glycemic levels, and screening and care for high-risk feet. Evidence suggests that effective risk factor management, patient education, and appropriate foot care can prevent the majority of NLEAs (1,2). In the last few decades, preventive care and the control of cardiovascular risk factors and glycemic levels have all improved significantly among U.S adults with diabetes (3,4). Accompanying these improvements have been reductions in rates of diabetes-related complications (5,6) and cardiovascular disease (6).

Although results of several recent studies (6–9) have shown encouraging trends in rates of NLEA in various populations and evidence of subgroup disparities among people with diabetes, no comprehensive studies have examined trends in NLEA rates or characteristics associated with diabetes-related NLEAs in the overall U.S. population. In this study, we used data from two nationally representative surveys to assess trends in NLEA hospital discharge rates by patients' diabetes status and to determine whether disparities in NLEA rates within the diabetic population persist.

RESEARCH DESIGN AND METHODS

Data sources

Our study was based on 1988–2008 data from the National Hospital Discharge Survey (NHDS) and the National Health Interview Survey (NHIS). The NHDS is a national probability survey of short-stay, nonfederal hospitals in all 50 states and the District of Columbia that collect discharge data, including patients' age, race, sex, marital status, expected sources of payment, length of stay, up to seven diagnoses (one primary and six secondary), and up to four surgical procedures. NHDS data collection methods have previously been described in more detail (10). We defined "NLEA discharges" as those for which the ICD-9-CM NLEA procedure codes 84.10–84.19 were listed in discharge records and ICD-9-CM diagnosis codes for an amputation after a traumatic injury (895–897) were not. We considered NLEAs to have been diabetes related if discharge records included the ICD-9-CM diagnosis code for diabetes (250).

We obtained estimates of the population with and without diabetes from the NHIS, a multistage probability survey of

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the civilian noninstitutionalized household population of the U.S. that collects information on the health of the U.S. population, including information on the prevalence and incidence of disease, the extent of disability, and the use of health care services. The methods used to conduct the survey have previously been described (11). The reported diabetes status of NHIS participants is based on their survey responses indicating whether a health professional had ever told them that they had diabetes.

Data analysis

We calculated annual NLEA hospital discharge rates by dividing the annual number of hospital patients whose discharge records indicated they had an NLEA from the NHDS by the annual estimated populations with and without diabetes from the NHIS. We compared trends in NLEA hospitalization rates by diagnosed diabetes status, and among those with diabetes we examined trends by age (40–64, 65–74, or ≥75 years), sex, and race (black or white). We restricted our analysis to survey respondents ≥40 years of age because NLEA is uncommon among people <40 years of age. In addition, we limited our analysis by race to blacks and whites because NHIS did not begin collecting Hispanic ethnicity data until 1997, although persons of Hispanic origin were included in each group. We used SUDAAN 10 software (Research Triangle Institute, Research Triangle Park, North Carolina) to obtain point estimates and SEs based on the Taylor series linearization method and to account for the complex sampling designs of the two surveys. We adjusted rates to the 2000 U.S. standard population using three age groups (40–64, 65–74, and ≥75 years), used the χ^2 test to determine whether differences between NLEA rates in various subgroups were significant, and calculated annual NLEA rate ratios by dividing the diabetes-related NLEA rate by the nondiabetes-related rate for each year.

We used Joinpoint Regression software (version 3.5; Statistical Methodology and Applications Branch and Data Modeling Branch, Surveillance Research Program, National Cancer Institute) to analyze trends in NLEA rates. Joinpoint regression involves the use of permutation tests to identify points where linear trends change significantly in either direction or magnitude. Each time period trend is described by the annual percentage change (APC), and the trend for the entire study period is described by the average annual percentage change (AAPC), which is a summary measure of trends accounting for the trend transitions with each APC. APC and AAPC were tested to determine whether the change was significantly different from 0, and results were considered statistically significant with a two-sided P value <0.05. Figure 1 illustrates the observed NLEA rates and the modeled trends.

RESULTS

NLEA in diabetic and nondiabetic populations aged ≥40 years

Although the number of U.S. residents with diagnosed diabetes increased dramatically from 5.4 million in 1988 to 17.1 million in 2008, the estimated number of diabetes-related NLEA discharge codes increased only from 52,868 in 1988 to 83,153 in 1996 and then decreased to 70,139 in 2008 (Figure 1). In contrast, we found no consistent trend in the number of NLEA discharge codes without diabetes.

Between 1988 and 2008, trends in age-adjusted NLEA differed for the diabetic and nondiabetic populations aged ≥40 years of age (Figure 1). Although age-adjusted NLEA rates in the nondiabetic population declined somewhat throughout the study period, this decline did not reach statistical significance (APC −0.7%; $P > 0.05$). In contrast, age-adjusted NLEA rates for the diabetic population increased in the early 1990s and then declined by 8.6% annually between 1996 and 2008 ($P < 0.01$). With change over the entire study period accounted for, the AAPC in age-adjusted NLEA rates was −4.9% ($P < 0.05$) in the diabetic population and 0.7% ($P > 0.05$) in the nondiabetic population. The absolute change in rates between 1988 and 2008 was also greater in the diabetic population than in the nondiabetic population (5.4 vs. 0.03 per 1,000 persons). Despite the much greater decrease in NLEA rates in the diabetic population, in 2008 the age-adjusted NLEA rate in the diabetic population was still approximately eight times the rate in the nondiabetic population (3.9 vs. 0.5 per 1,000 persons).

NLEA rates in the diabetic population by demographic characteristics

Among persons with diabetes, NLEA rates were highest among those aged ≥75 years and lowest among those aged 40–64 years throughout most of the 20-year period (Table 1). NLEA rates began to decrease in 1996 in all age groups, although the APC from 1996 to 2008 was significantly greater among those aged ≥75 years than among those aged 40–64 or 65–74 years (−10.3 vs. −7.5 and −7.7%, respectively; $P < 0.05$ for both comparisons). Between 1988 and 2008, the absolute difference in rates between those aged ≥75 years and those aged 40–64 years declined from 12.8 to 3.0 per 1,000 persons.

Overall, between 1996 and 2008 NLEA rates decreased by 67%. We also calculated what this decrease would have been had the age-race–specific rates of diabetes not changed over the time period but instead changed in the same way as they did in the general population. Under this assumption of no change in diabetes prevalence rates, NLEA rates decreased by 34%. Throughout the study period, the age-adjusted NLEA rates were significantly higher among men than among women and also higher among blacks than among whites (χ^2 test, $P < 0.05$). After showing no consistent trend from 1988 to 1996, the age-adjusted rate among men started to decrease in 1996. Among women, the decrease started 3 years later in 1999. The AAPC in rates across the entire time period, however, was the same for men and women (−5.4% annually).

Among blacks, the age-adjusted NLEA rates decreased over the entire study period (APC −3.7% per year; $P < 0.05$) (Table 1). In contrast, the age-adjusted rate among whites showed no consistent trend from 1988 to 1996 but declined rapidly between 1996 and 2008 (APC −9.1% per year; $P < 0.05$). The AAPC from 1988 to 2008 was −6.1% for whites and −3.7% for blacks.

CONCLUSIONS—Our results showing substantial recent decreases in NLEA rates in the U.S. diabetic population aged ≥40 years are consistent with the results of an earlier study in a diabetic population (6), studies among U.S. subgroups such as the Medicare population (8) and veterans served by the Veterans Health Administration (9), and studies from Finland and England (7,12). On the basis of nationally representative data, we estimated that NLEA rates in the U.S. diabetic population and in all demographic groups that we examined began to decline in the mid-1990s. Although the decline in the age-adjusted NLEA rate was substantially greater in the diabetic population than in the nondiabetic population, the NLEA rate in 2008 was still

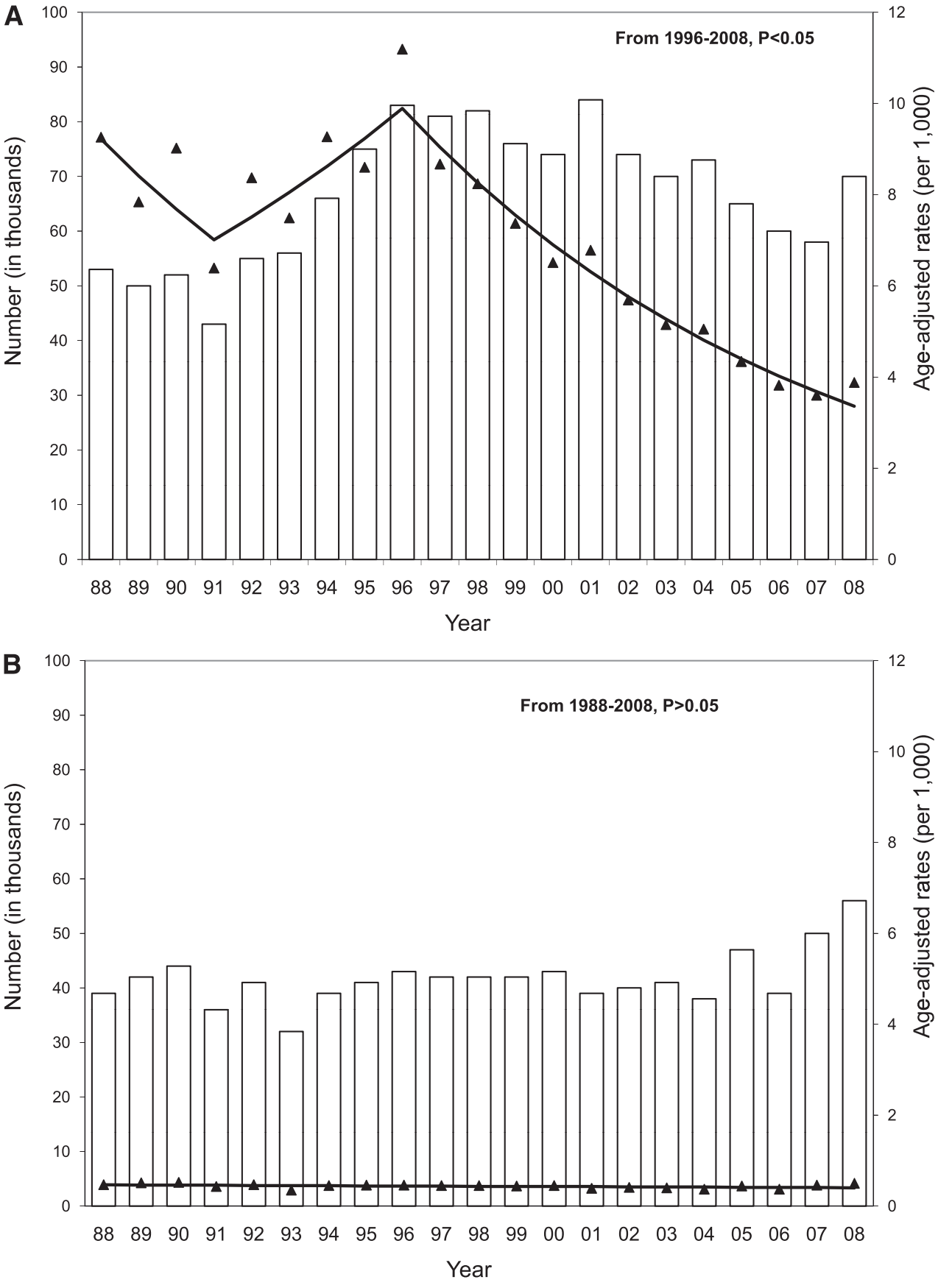

Figure 1—*Estimated annual number of NLEAs and age-adjusted NLEA rates among U.S. residents aged ≥40 years by diabetes status, 1988–2008.* A*: Diabetes-related NLEA.* B*: Nondiabetes-related NLEA.* □*, number of discharges;* ▲*, observed NLEA rates;* —*, modeled trends in rates.*

Table 1—*Hospital discharge rates and trend analysis of diabetes-related NLEA among subjects aged ≥40 years: U.S., 1988–2008*

	Rates*		Overall trend	Trend 1†		Trend 2		Trend 3	
	1988	2008	AAPC	Period	APC	Period	APC	Period	APC
Overall									
Total	9.8	4.1	−5.2‡	1988–1991	−9.4	1991–1996	7.4‡	1996–2008	−9.0‡
Total§	9.3	3.9	−4.9‡	1988–1991	−8.7	1991–1996	7.1‡	1996–2008	−8.6‡
By age (years)									
40–64	7.4	3.2	−3.4‡	1988–1996	3.1	1996–2008	−7.5‡		
65–74	7.6	4.9	−3.5‡	1988–1996	3.4	1996–2008	−7.7‡		
≥75	20.2	6.2	−5.5‡	1988–1996	2.2	1996–2008	−10.3‡		
By sex§									
Male	13.3	6.0	−5.4‡	1988–1991	−13.4	1991–1996	8.6	1996–2008	−8.7‡
Female	5.6	1.9	−5.4‡	1988–1999	−0.3	1999–2008	−11.2‡		
By race§**									
White	7.8	2.9	−6.1‡	1988–1991	−16.1	1991–1996	8.4	1996–2008	−9.1‡
Black	8.4	4.9	−3.7‡	1988–2008	−3.7‡				

*Per 1,000 persons with diabetes. †Joinpoint analyses of trend showing up to two joinpoints. ‡*P* value <0.05. §Age-adjusted based on the 2000 U.S. standard population. **Racial categories include subjects of Hispanic and non-Hispanic origin.

approximately 8 times higher in the diabetic population, indicating a need for additional efforts to further reduce the excess risk for NLEA among persons with diabetes.

Our finding that men had higher NLEA rates than women was consistent with results of previous studies (13–15), as was our finding that blacks had higher rates than whites (9,16,17). One reason for the higher rates among blacks may be that peripheral arterial disease and peripheral neuropathy, two conditions that lead to amputation, are more common among blacks than whites (18,19). In addition, disparities in NLEA rates have been shown to decrease after adjustments for NLEA risk factors such as low education, poverty, smoking, lack of access to care, and hypertension (20,21). Although the NHDS data did not allow for analysis of racial/ethnic minority groups other than blacks, NLEA rates are disproportionately higher among Hispanics and American Indians with diabetes compared with those among whites (17,22). Even though disparities in NLEA rates by age, race, and sex persisted throughout the study period, rates did decrease significantly in all demographic groups examined. The large reduction in rates among persons with diabetes ≥75 years of age was particularly encouraging; however, reasons for the decline in this age group remain unknown. Continued efforts are needed to decrease the prevalence of NLEA risk factors and improve foot care among certain subgroups within the U.S. diabetic population that are at higher risk.

During the study period, the prevalence of diabetes steadily increased. When NLEA rates were examined assuming no growth in diabetes prevalence rates, the decline in NLEA rates between 1996 and 2008 was reduced by half. The growth in the prevalence of diabetes is likely due to both improved survival among persons with diabetes and the growth in the number of those who are newly diagnosed (i.e., increased incidence). Improved survival among individuals with diabetes could lead to longer diabetes duration and a greater opportunity to develop NLEA. On the other hand, increased incidence may have resulted in a greater number of individuals with milder disease, detected earlier in the disease process, who have not had diabetes long enough to develop complications. Once these patients with new-onset, milder disease have had diabetes long enough, it is possible that the encouraging trends in diabetes-related NLEA will reverse.

In the U.S., the prevalence of cardiovascular risk factors has declined (23) and the rates of preventive care practices, including self-management training for people with diabetes, have improved (24). Further, surveillance data showing declining trends in hospitalizations for peripheral arterial disease and ulcer/inflammation (http://www.cdc.gov/diabetes/statistics/hosplea/diabetes_complications/fig2_pop.htm), precursor conditions for NLEA, suggest improvements in recognizing and managing high-risk feet among the diabetic population. Because our study was based on cross-sectional data, we were unable to identify the reasons behind the reductions in NLEA rates; however, our finding that the reduction in rates was substantially higher in the diabetic population than in the nondiabetic population suggests that the rate reduction in the diabetic population may be partly attributable to improved diabetes care management, differential risk factor improvement, or the differential impact of such improvements.

Our study used nationally representative surveys to estimate NLEA trends for persons with and without diabetes and to examine trends among persons with diabetes by demographic characteristics; however, it had four limitations. First, we underestimated the size of the total diabetic population because the population estimates did not include persons with undiagnosed diabetes or persons residing in nursing homes. Second, our results may not be representative of the overall U.S. population because the NHDS does not include data on NLEAs performed in long-term hospitals, federal hospitals (e.g., Veterans Health Administration hospitals), or outpatient settings. Third, because the NHDS samples hospital discharge records rather than records of individual patients, patients hospitalized more than once in a year may have been counted more than once. Finally, our estimates of race-specific NLEA rates are likely lower than the actual rates because discharge records for a large proportion of patients did not include a racial designation. In addition, previous study results suggest that patients whose discharge records lack a racial designation are disproportionately white (25), a bias that may have further confounded our results.

However, the racial disparities in NLEA rates that we found are consistent with those found in studies that did not rely on hospital discharge survey data (8,17,20).

Public health implications

The NLEA rate in the U.S. diabetic population aged ≥40 years is declining both overall and in all demographic groups we examined. However, disparities in NLEA rates persist, and people with diabetes remain at great risk for NLEA. Further decreases in rates of NLEA will require continued awareness of diabetes and its complications among patients and providers as well as comprehensive interventions to reduce the prevalence of risk factors for NLEA and to improve foot care and overall care for people with diabetes, particularly for those in subpopulations at higher risk for NLEA.

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