

Estimating the Prevalence of Limb Loss in the United States: 2005 to 2050

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Objective: To estimate the current prevalence of limb loss in the United States and project the future prevalence to the year 2050.

Design: Estimates were constructed using age-, sex-, and race-specific incidence rates for amputation combined with age-, sex-, and race-specific assumptions about mortality. Incidence rates were derived from the 1988 to 1999 Nationwide Inpatient Sample of the Healthcare Cost and Utilization Project, corrected for the likelihood of reamputation among those undergoing amputation for vascular disease. Incidence rates were assumed to remain constant over time and applied to historic mortality and population data along with the best available estimates of relative risk, future mortality, and future population projections. To investigate the sensitivity of our projections to increasing or decreasing incidence, we developed alternative sets of estimates of limb loss related to dysvascular conditions based on assumptions of a 10% or 25% increase or decrease in incidence of amputations for these conditions.

Setting: Community, nonfederal, short-term hospitals in the United States.

Participants: Persons who were discharged from a hospital with a procedure code for upper-limb or lower-limb amputation or diagnosis code of traumatic amputation.

Interventions: Not applicable.

Main Outcome Measures: Prevalence of limb loss by age, sex, race, etiology, and level in 2005 and projections to the year 2050.

Results: In the year 2005, 1.6 million persons were living with the loss of a limb. Of these subjects, 42% were nonwhite and 38% had an amputation secondary to dysvascular disease with a comorbid diagnosis of diabetes mellitus. It is projected that the number of people living with the loss of a limb will more than double by the year 2050 to 3.6 million. If incidence

rates secondary to dysvascular disease can be reduced by 10%, this number would be lowered by 225,000.

Conclusions: One in 190 Americans is currently living with the loss of a limb. Unchecked, this number may double by the year 2050.

Key Words: Amputation; Diabetes mellitus; Peripheral vascular diseases; Prevalence; Rehabilitation; Wounds and injuries.

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IN THE UNITED STATES, an estimated 185,000 persons undergo an amputation of an upper or lower limb each year.¹ Although patterns in the incidence of limb loss secondary to diabetes mellitus,²⁻¹⁵ dysvascular disease,^{2,16-21} trauma,^{2,22-24} and malignancy of the bone and joint^{2,25} have been elucidated over the past 30 years, little is known about prevalence or the number of persons currently living with the loss of a limb. Establishing the prevalence of and future trends in limb loss is important for health care planning and for the rational allocation of resources. Of particular concern is the impact that changing demographics and increasing rates of diabetes will have on the demand for prosthetic devices and related services.

The most recent estimates of the prevalence of limb loss are derived from the 1996 National Health Interview Survey (NHIS).²⁶ At that time, it was estimated that approximately 1.2 million persons were living with the loss of a limb. More recent estimates are not available from the NHIS because the condition defined as "absence of an extremity" is no longer listed as one of 15 principal conditions and impairments that trigger further questions in the interview. In addition, the NHIS precluded relevant estimates by level of amputation and etiology due to the limited number of persons with limb loss in the sample.

In the absence of a national surveillance system for monitoring limb loss, we sought to apply methods developed by Brookmeyer and Gray²⁷ to estimate the number of persons living with the loss of a limb in the year 2005 with projections to 2050. Using age- and sex-specific disease incidence rates together with mortality data, Brookmeyer and Gray constructed estimates of the prevalence of Alzheimer's disease in persons 60 years of age and older. We applied their methodology to include a broader population of all ages (0-85y) and differences by race and ethnicity. We also made modifications to allow for varying relative risks of death associated with limb loss by age. We constructed current and future estimates of limb loss prevalence by age, sex, and race and by level and etiology of the limb loss. We also evaluated the impact of increasing rates of underlying disease as well as promising interventions on future prevalence. All calculations were performed using S-Plus^a based on algorithms published by Brookmeyer and Gray.²⁸

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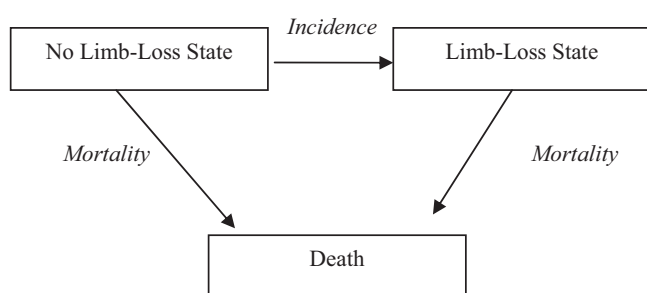


Fig 1. Schematic illustration of multistate model for limb loss. Transition to limb-loss state occurs with incidence rate. Mortality rate transitions persons without limb loss from the no-limb-loss state to death, and the transition from limb loss to death is a function of mortality rate and the relative risk of mortality associated with limb loss. Mortality in the limb-loss state is the relative risk multiplied by the background mortality in the no-limb-loss state.

METHODS

Overview

Our methodology is based on a multistate probabilistic model in which persons may move from a state without limb loss to the limb-loss state.²⁷ Persons are at risk of death in each state. The model is illustrated schematically in figure 1. The input parameters to the model are the transition probabilities, which are the probabilities of moving from 1 state to the other. As described below, these transition probabilities are allowed to depend on age and calendar year. The model calculations are performed in discrete time where the unit of time is a calendar year. Formulas have been derived for estimating the age-specific prevalence rate of limb loss under this model.²⁷ The formula for the age-specific prevalence rate of limb loss takes the form p_1/p_2 , where p_1 is the probability of being alive at a given age with limb loss and p_2 is the probability of living to that given age (with or without limb loss). The formulas for p_1 and p_2 depend on the transition probabilities shown in figure 1, including the incidence rate of limb loss, the mortality rate among persons without limb loss, and the mortality rate among persons with limb loss.

By this method one may estimate, for any year past or present, the proportion of living persons of any given age who have experienced limb loss. This process is applied to future years using projected mortality data. Application of these proportions to current (age- and year-specific) population totals provides estimates of the total number of people currently living with limb loss; estimates of future totals are likewise derived from projected population trends in age and mortality.²⁷

In this analysis, estimates of prevalence and projections into the future were constructed using age-, sex-, and race-specific incidence rates combined with age-, sex-, and race-specific assumptions about mortality. Incidence rates were assumed to remain constant over time and applied to historical mortality and population data along with the best available estimates of relative risk, future mortality, and future population projections. To investigate the sensitivity of our projections to increasing or decreasing incidence, we developed alternative sets of estimates of limb loss related to dysvascular conditions based on assumptions of a 10% or 25% increase or decrease in the incidence of amputations for these conditions.

Later we discuss the sources of information and methods used for estimating the parameters needed to apply this technique: (1) age-, sex-, and race-specific incidence of amputa-

tions by type and etiology; (2) historic estimates and annual projections of the U.S. population by age, sex, and race; (3) historic and future estimates of U.S. mortality rates by age, sex, and race (to estimate mortality among those living without the loss of a limb); and (4) relative risks of dying with and without limb loss.

Incidence Rates of Limb Loss

Data from the Healthcare Cost and Utilization Project, Nationwide Inpatient Sample (HCUP-NIS) from 1988 through 1999 were used to identify a study population and incident cases of limb-loss discharges over the 12-year study period. The HCUP is a stratified probability sample designed to approximate 20% of all community, nonfederal, short-term hospitals in the United States. Hospital-specific weights were derived to obtain national estimates of discharge parameters. Selection of the study population followed the algorithm described in Dillingham et al.² First, patients discharged with a procedure code for upper-limb or lower-limb amputation (*International Classification of Diseases, Ninth Revision, Clinical Modification* [ICD-9-CM] codes 84.00–84.09, 84.1–84.19, 84.91) or a diagnosis code of traumatic amputation (ICD-9-CM codes 885.0–887.7, 895.0–897.7) were identified. Next, these patients were categorized hierarchically into 1 of 4 mutually exclusive categories defined by the etiology of their amputations: (1) trauma related (ICD codes 810–839, 880–884, 885–887.7, 925–929, or 958–959), (2) cancer related (ICD codes 170.4–170.8, 171.2–171.3, or 172.6–172.7), (3) dysvascular (ICD codes 040.0, 250.0–250.9, 440.0–440.9, 442.0–442.9, 443.0–443.9, 682.0–682.9, 686.0–686.9, 707.0–707.9, 728.86, 730.0–730.9, or 785.0–785.9), or (4) other etiology, which includes newborn discharges with a congenital reduction anomaly and discharges for amputations due to complications of procedures, internal derangement of joints, and other joint disorders. In addition, those classified as “dysvascular” with a comorbidity of diabetes (ICD codes 250.0–250.9) were classified as having undergone an amputation related to diabetes. Because those in the “other etiology” category could not easily be identified as belonging to 1 of the other 4 groups, they were excluded from further analysis. They represent less than 3% of all limb-loss-related hospitalizations. As described in Dillingham,² cases not presumed to be new or incident cases of limb deficiency and amputation were excluded from the analysis.

Etiology-specific limb-loss-related discharges were further classified according to level of amputation (coded as upper-limb loss or lower-limb loss) and major versus minor limb loss. *Major limb loss* was defined as amputation above the elbow, below the elbow, above the knee, and below the knee, or the foot. *Minor limb loss* was defined as amputation of fingers, hands, or toes.²⁹ In the case of 2 or more amputations, the most proximal amputation was used for categorizing as major or minor or upper or lower.

A major limitation of the HCUP-NIS for estimating incidence is related to the fact that multiple hospitalizations for amputation (of the same or different limb) cannot be identified. Several studies^{30–32} have now shown, however, that among persons undergoing amputation for vascular disease, the risk of reamputation is high. Sambamoorthi et al³¹ concluded from their study of U.S. veterans with diabetes that a little more than one quarter of veterans undergoing an initial amputation of a lower limb may have a repeat amputation. In a study using national claims data from the Center for Medicare & Medicaid Services, Dillingham et al³² found that 26% of Medicare beneficiaries undergoing a dysvascular amputation of a lower limb were rehospitalized within 12 months for a subsequent amputation. Given these high rates of reamputation, we reduced our

estimates of the annual incidence for dysvascular amputation-related discharges by 26%.

Age-specific incidence rates were calculated by sex and race for the 12-year study period using the sum of the annual national population data for each of the 12 years in the study period. Population data for the years 1988 through 1999 were obtained from the U.S. Bureau of the Census and the National Center for Health Statistics.³³ For the years 1988 and 1989, national quarterly intercensal resident populations as of July 1 were used. For the years 1990 through 1999, annual time series of state population estimates by age, sex, race, and Hispanic origin were used. Although estimates of incident cases of amputation were available from the HCUP-NIS for 6 race and ethnicity subgroups, the constraints of using historical population and mortality data necessitated further grouping of race and ethnicity into only 2 categories: white and nonwhite. Because not all states report race in their hospital discharge abstract systems, this parameter was unknown for approximately 35% of patients in the database. These patients were grouped according to the race distribution of patients with known race at each age (1–85y).

Because the age-specific incidence rates by sex, race, and amputation etiology displayed spikes at various ages that were incompatible with the likely association between age and disease, the data were smoothed using a moving average smoother with a window of 5 years. For example, the age-specific incidence rates at ages 10 to 14 years were averaged to derive a smoothed value at age 12 years, rates for ages 11 to 15 years were averaged to obtain a value for age 13 years, and so forth. The resulting curve reflects a smooth trend in age-specific incidence rates.³⁴

Population Projections

Annual population projections by age, sex, and race were also obtained from the U.S. Census Bureau, Population Division.³⁵ For the years 2000 through 2050, the middle series data were used. This middle series data uses medium assumptions about future fertility, life expectancy, and net immigration to project the population. Under these assumptions, fertility and net immigration are assumed to remain nearly constant, and life expectancy is projected to increase to 83 years by 2050.³⁵

Mortality Rates for Persons Without Limb Loss

Mortality rates based on national vital statistics were used to approximate age-, sex-, and race-specific mortality data for persons living without limb loss.³⁶⁻⁴⁰ These data were available in 5-year age intervals as of 1933 (10-y intervals for years 1900–1932). Simple smoothing techniques as described by Brookmeyer and Gray²⁷ were used to calculate age-specific mortality rates for single years of ages 1 to 85. For each calendar year, regression methods were used to interpolate mortality rates. Specifically, the log of the mortality rate was related to a linear function of age. We fit separate regression models in each of 3 age groups (1–14y, 15–49y, >50y of age) to allow for flexibility in the shape of the mortality rate curve over the life span. These groupings of age reflect 3 main periods of the human life span. From ages 1 to 14 years, mortality rates are relatively constant, with decreasing rates at younger years. The middle life reflects the beginning of the trend of increasing mortality rates, and the third period reflects later life, when mortality rates begin to increase more rapidly.

For ages 60 years and above, the past 15 years of mortality data were used to predict future mortality trends.²⁷ For ages less than 60 years mortality was kept constant, because data for some of the age, race, and sex groups were sparse and projected

unreliable and unrealistic trends in mortality that have not been documented in the literature. For this age group, a 5-year average mortality, based on years 1995 through 1999, was calculated and held constant for future years.

Mortality Rates for Persons With Limb Loss

Also needed for the calculation were mortality rates for persons living with the loss of a limb. These rates can be calculated if the relative risk of death for those with limb loss compared with those without limb loss is known. Because these relative risks per se are unavailable, estimates of the relative risk for the underlying disease that precipitated the amputation were used as proxies. A relative risk of 1.0 was assumed for persons undergoing amputation because of a traumatic injury based on the assumption that there was no underlying disease that led to the limb loss. Relative risks of death for those with and without cancer were calculated using mortality rates for bone and joint cancer obtained from the Surveillance Epidemiology and End Results program of the National Cancer Institute⁴¹ and mortality rates for the general population. Based on the availability of the mortality data, relative risks were calculated by sex and race. Estimates ranged from 5.4 (white women) to 6.9 (nonwhite men). Relative risks for persons undergoing amputation for dysvascular conditions and diabetes were estimated using published data from a limited number of cohort studies.^{42,43} For the diabetes group, relative risks were available by sex, race, and 3 age groups: less than 45 years of age, 45 to 64 years, and 65 years and older. Relative risks for non-Hispanic whites were applied to those in our study defined as white, and relative risks for non-Hispanic blacks were applied to those defined as nonwhite. Estimates of these relative risks ranged from 1.4 to 6.2. Relative risks for limb loss secondary to dysvascular disease were available by sex only (2.5 for women, 3.3 for men).

RESULTS

2005 Estimates

An estimated 1.6 million persons were living with the loss of a limb in the year 2005. Table 1 illustrates how prevalence varies by etiology of the limb loss, age, sex, and race. Amputations secondary to dysvascular disease (n=846,000) account for most (54%) cases and of these, over two thirds have a comorbid diagnosis of diabetes (n=592,000). Limb loss secondary to trauma accounts for an additional 45% of the prevalent cases (n=704,000) and cancer for the remaining less than 2% (n=18,000). These percentages vary by age because of the patterns in the incidence of the underlying disease or injury resulting in amputation. Across all etiologies, 42% of the persons living with the loss of a limb are 65 years or older (n=665,000); 65% are men (n=1,026,000), and 42% are nonwhite (n=652,000). As summarized in table 2, a total of 65% of persons living with the loss of a limb underwent an amputation to the lower extremity (n=1,027,000), and over one half of these amputations (n=623,000) were major (ie, excluding toes). In contrast, of the total number living with the loss of an upper limb, only 8% (n=41,000) were categorized as major (ie, excluding fingers). Estimates of prevalence by type and level of limb loss vary substantially by etiology (see table 2).

Projections and Sensitivity of Estimates to Increases and Decreases in the Incidence of Amputations

Over the next 45 years, the number of persons living with the loss of a limb is expected to more than double from 1.6 million in 2005 to 3.6 million in 2050 (table 3). Those undergoing

Table 1: Age-Specific Estimates of Prevalence by Sex, Race and Ethnicity, and Etiology (in thousands): Year 2005, United States

Etiology, Sex, and Race and Ethnicity	All Ages	Under 65 Years				65 Years and Over		
		Total	Under 18	18–44	45–64	Total	65–74	75–100
All etiologies	1568	903	25	277	601	665	323	342
Sex								
Male	1026	668	16	218	433	358	199	159
Female	542	235	9	58	168	306	124	183
Race and ethnicity								
Nonwhite women	195	92	4	23	65	103	47	56
Nonwhite men	457	313	9	113	190	145	83	61
White women	347	143	5	35	104	203	76	127
White men	569	355	7	105	243	214	116	98
Dysvascular disease: total								
Total	846	375	2	52	321	471	228	242
Nonwhite women	151	59	*	8	50	92	42	50
Nonwhite men	185	101	*	17	84	84	50	34
White women	249	82	*	10	71	167	63	104
White men	261	133	*	17	116	128	73	54
Dysvascular disease with comorbidity of diabetes								
Total	592	191	*	18	174	400	162	239
Nonwhite women	106	31	*	3	28	75	28	47
Nonwhite men	146	60	*	6	54	86	44	42
White women	164	54	*	5	49	110	44	66
White men	176	47	*	4	43	129	45	84
Trauma								
Total	704	513	22	218	273	192	93	99
Nonwhite women	41	30	3	14	14	11	5	6
Nonwhite men	270	209	9	95	105	61	33	28
White women	92	57	4	23	30	35	13	22
White men	301	216	6	86	124	85	42	43
Cancer								
Total	18	15	*	7	7	3	2	*
Nonwhite women	3	2	*	1	*	*	*	*
Nonwhite men	3	3	*	1	*	*	*	*
White women	6	5	*	2	2	1	*	*
White men	7	6	*	2	3	*	*	*

NOTE. Totals may not equal sum because of rounding.
*Represents less than 1000.

amputations due to dysvascular conditions account for most of the increase, with totals increasing from less than 1 million in 2005 to 2.3 million in 2050. These projections assume that age-, race-, and sex-specific incidence rates of amputation remain constant over time. The increase in prevalence is driven by the aging population and the high rates of dysvascular conditions among older adults.

Amplification or attenuation of the increase in prevalence of limb loss associated with dysvascular conditions is displayed in figure 2, assuming either a 10% or 25% increase or decrease in incidence.

DISCUSSION

To our knowledge, this is the first study since 1996 to provide comprehensive estimates of the prevalence of limb loss

Table 2: Estimates of Prevalence by Type and Level of Limb Loss and Etiology (in thousands): Year 2005, United States

Etiology	Total	Lower Limb		Upper Limb	
		Major	Minor	Major	Minor
All etiologies	1568	623	404	41	500
Dysvascular disease: total	846	504	302	5	34
Dysvascular disease with comorbidity of diabetes	592	359	212	3	19
Trauma	704	106	101	34	464
Cancer	18	13	1	2	1

NOTE. Totals may not equal sum because of rounding. Cases missing information regarding level (34%) were assigned to specific level according to distribution.

Table 3: Projected Prevalence of Limb Loss by Etiology and Age (in thousands): Years 2005, 2010, 2020, 2050, United States

Etiology and Age	2005	2010	2020	2050
Total	1568	1757	2213	3627
Under 65 years	903	1005	1124	1408
Over 65 years	665	752	1088	2219
Dysvascular disease: total				
Total years	846	969	1285	2272
Under 65 years	375	434	503	624
Over 65 years	471	534	782	1648
Dysvascular disease with comorbidity of diabetes				
Total	592	674	899	1667
Under 65 years	191	225	266	333
Over 65 years	400	449	632	1334
Trauma				
Total	704	769	906	1326
Under 65 years	513	555	604	764
Over 65 years	192	214	302	562
Cancer				
Total	18	19	22	29
Under 65 years	15	16	17	21
Over 65 years	3	3	5	8

NOTE. Totals may not equal sum because of rounding.

in the U.S. population. The NHIS estimated 1.2 million cases of limb loss for 1996.²⁶ Our result of 1.6 million in 2005 appears to be consistent with these results. The NHIS consisted of 40,000 households and includes cases of congenital limb loss and those treated on an outpatient basis, but it excludes persons who are institutionalized and those with amputations of only fingertips or toes. Our estimates were based on HCUP-NIS hospital discharge data that include both minor and major amputations but exclude congenital limb loss and amputations performed at federal facilities.

Our findings show striking patterns in the prevalence of limb loss that are not evident from an analysis of more widely available data on the incidence of amputations. First, although trauma accounts for only 16% of all amputation-related hospital discharges, they account for an estimated 45% of the prevalent cases of limb loss. This difference is due to the fact that

over two thirds of amputations due to trauma occur among adolescents and adults below the age of 45 years.²² In comparison, approximately 64% of all amputations due to dysvascular disease occur among older adults ages 65 years or older.² Thus, even though overall rates of amputation increase dramatically with age, with 57% of the incident cases occurring among older adults 65 years and over, there are close to 1 million persons living with the loss of a limb who are below the age of 65 years (302,000 below the age of 45y). These people will have prosthetic and health service needs for many years to ensure high-quality, active, and productive lives.

Most striking, however, are the projected trends for the number of people living with the loss of a limb. This increase is related to the aging of the population and the associated increase in the number of people living with dysvascular conditions, especially diabetes.⁴⁴ The prevalence of diabetes in the United States is projected to nearly double by the year 2030 solely because of changes in the demographic composition of the population. Our estimates of limb loss reflect, and indeed magnify, these trends. Even assuming that age-, sex-, and race-specific rates of both diabetes and diabetes-related amputations remain unchanged, the number of people with diabetes who are living with the loss of a limb will nearly triple by the year 2050. Overall, the prevalence of limb loss will more than double from 1.6 to 3.6 million people. Given the increase in the prevalence of obesity and the known relationship between obesity and diabetes, a projected increase in the incidence of amputations secondary to dysvascular conditions is likely.⁴⁵⁻⁴⁹

Figure 2 highlights the potential impact of this increase on the projected number of Americans living with the loss of a limb.

Our results also underscore the profound disparities in limb loss by race and ethnicity. Among underrepresented minority populations in the United States, the risk of amputation has been noted to be 2 to 3 times that of non-Hispanic whites.^{4,5,9,12,16,18,19,21,50} Recent studies have suggested that this variation in risk by race and ethnicity may be attributed to poverty⁵¹ and differences in access to primary care and preventative services.^{18,52,53} Our estimates of prevalence show

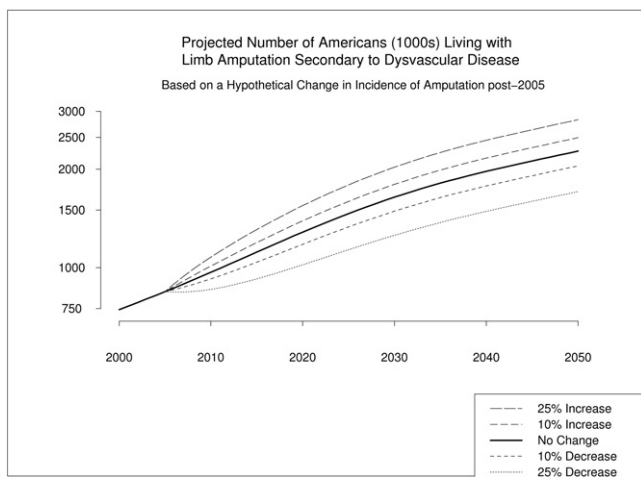


Fig 2. Projected number of Americans living with limb amputation secondary to dysvascular disease (log scale) from year 2000 to 2050.

that 1 in 250 white Americans are living with the loss of a limb compared with 1 in 90 nonwhites.

Clearly, public health efforts to reduce the prevalence of limb loss must be directed at both primary and secondary prevention efforts. In addition to reducing the underlying risk of disease and injury, the prevalence of limb loss can be significantly affected by preventing amputation as a secondary consequence of dysvascular disease. A goal of *Healthy People 2010* is to reduce the number of lower-extremity amputations in persons with diabetes by 55%, from 4.1 per 1000 to 1.8 per 1000 persons.⁵⁴ Interventions, such as diabetes self-management education and targeted foot screening programs, have been shown to be effective in reducing the risk of foot ulcers and subsequent amputation.⁵⁵⁻⁵⁸ Given that nearly 85% of lower-extremity amputations are preceded by a foot ulcer,⁵⁹⁻⁶² these interventions, if broadly implemented, could have a significant impact on the prevalence of limb loss (see fig 2). However, barriers, including both economic and individual motivational barriers, may preclude participation in these programs by those most at risk.

Study Limitations

Our estimates of prevalence must be interpreted in light of the study limitations. Although deriving confidence intervals for our estimates is beyond the scope of the methodology,²⁷ we acknowledge that there are many sources of variability in the data we used to estimate incidence, mortality, population, and relative risk. The greatest source of uncertainty in our estimates is derived from the limited data available on the incidence of first amputations by patient demographics and by level and etiology of the amputation. Although HCUP-NIS hospital discharge data are nationally representative and provide comprehensive data on limb-loss related discharges, they are limited in several important ways.² These include the restriction of the database to discharges from nonfederal hospitals and the fact that the unit of observation in the HCUP-NIS is the discharge rather than the person. As discussed above, we have attempted to correct the number of annual discharges associated with a dysvascular amputation by an estimate of the rate of reamputation. However, because of the relative paucity of comprehensive estimates of reamputation rates by patient demographics and etiology of the amputation, we applied a constant correction for all dysvascular amputations.

The restriction to nonfederal hospitals discounts amputations performed at Veterans Health Administration hospitals, which have been estimated to account for up to 10% of all amputation-related discharges performed in the United States.⁶³ It also excludes amputations resulting from armed conflicts, which are initially treated in military hospitals. Estimates of amputations during Operation Iraqi Freedom and Operation Enduring Freedom alone exceed 600.⁶⁴ Coupled with the fact that we excluded limb loss resulting from congenital conditions (which account for <1% of total incidence) and a small number of amputations performed for reasons other than those related to trauma, cancer, or vascular conditions (accounting for ≈2% of total incidence), our estimates of prevalence may well be conservative.

It is also important to point out that for some subgroups, the HCUP-NIS data are sparse, leading to less precise estimates of incidence. In addition, our definition of diabetic amputations includes all dysvascular amputations that had a comorbid diagnosis of diabetes. We cannot strictly identify amputations resulting as a consequence of diabetes. Perhaps most important, our crude definition of race (white and nonwhite), used to conform to historic data, limits the applicability of the data to the development of more specific estimates by race and eth-

nicity. In addition, data on race/ethnicity were missing for one third of the discharges. Previous studies⁶⁵⁻⁶⁷ have shown that missing information on race and ethnicity in administrative datasets is typically nondifferential, with a larger proportion of missing data being for nonwhite patients. These studies suggest that our estimates of the prevalence among nonwhites might understate the extent of disparities in limb loss.

In addition to the limitations in our estimates of incidence, we made several assumptions about mortality rates for persons living with the loss of a limb. Because the relative risk of death for those with limb loss compared with those without limb loss is unknown, we relied on available estimates of the relative risk for the underlying disease that precipitated the amputation. It is not clear how these assumptions might affect our overall estimates of prevalence. It is important to emphasize, however, that although estimates of the absolute prevalence of limb loss are sensitive to the assumptions about age- and race-specific estimates of incidence and estimates of the relative risk of dying after an amputation, the proportional growth in the number of people living with the loss of a limb is largely unaffected, because it is driven by the aging of the population.

CONCLUSIONS

This study estimated the prevalence of limb loss in the United States and projected these numbers into the future. As additional, more precise estimates of the incidence and mortality consequences of amputation become available, it will be possible to refine the magnitude of our estimates. Regardless of some uncertainty associated with the absolute size of our estimates, it is clear that the number of people living with the loss of a limb will continue to increase, driven in particular by the aging of the population and the associated increase in the incidence of diabetes mellitus and dysvascular disease. This relative increase is concerning and warrants further investigation into the causes, consequences, and prevention of limb loss. Our estimates also draw attention to the need for effective programs and policies that will guarantee access to prosthetic limbs, assistive devices, and appropriate health and prosthetic services to ensure the well-being of the already large number of persons living with the loss of a limb.

This methodology can be applied to other types of chronic and nonrelapsing disease. Given the general population assumptions under which this extended methodology can be applied, its use has widespread application for estimating disease prevalence for any chronic, nonrelapsing conditions for which reliable estimates of incidence are available.

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