Rates of Lower-Extremity Amputation and Arterial Reconstruction in the United States, 1979 to 1996

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ABSTRACT

Objectives. This report describes trends in the rates of lower-extremity amputation and revascularization procedures and vascular disease risk factors.

Methods. We analyzed trends in National Hospital Discharge Survey data for 1979 through 1996 and in National Health Interview Study data for 1983 through 1994.

Results. Despite a decline between 1983/84 and 1991/92, by 1995/96 the rate of major amputation had increased 10.6% since 1979/80. The earlier 12-year decline was positively correlated with reductions in the prevalence of smoking ($r = 0.88$, $P < .0001$), hypertension ($r = 0.65$, $P = .02$), and heart disease ($r = 0.73$, $P = .007$), but not diabetes ($r = -0.33$, $P = .29$). During the 1980s, amputation and angioplasty rates were inversely correlated ($r = -0.75$, $P = .001$), but the decline in amputation rates occurred before the increase in angioplasty. The major amputation rate, which has increased since 1993, was 24.95 per 100 000 people in 1996.

Conclusions. Major amputation rates fell in the years following the diffusion of distal bypass surgery but before the widespread use of peripheral angioplasty. Because disease prevalence and primary amputation rates are unknown, it is difficult to estimate the contribution of recent improvements in vascular surgery to limb preservation. (*Am J Public Health.* 1999;89:1222–1227)

Referral center studies have reported highly successful arterial patency results after surgical or endovascular treatment of lower-extremity vascular disease.[1] Yet, despite significant growth in specialized vascular surgery manpower and facilities, it has proven difficult to measure the population-based medical effectiveness of improvements in vascular medicine and surgery over the last 2 decades. One approach to this complex issue is to study population-based rates of lower-extremity amputation, the patient outcome most closely associated with interventional management of peripheral vascular disease.[2]

The largest US population-based study of trends in lower-extremity amputation rates was based on Maryland hospital claims data from 1979 to 1989. This controversial study found no change in amputation rates despite a significant increase in rates of vascular surgery and lower-extremity angioplasty.[3–5] More recently, investigators from the Mayo Clinic found a 50% reduction in major amputations associated with the increased use of lower-extremity bypass surgery and angioplasty between 1973 and 1992 in Olmsted County, Minnesota.[6]

This report, based on National Hospital Discharge Survey (NHDS) estimates from the National Center for Health Statistics, reviews national trends in age-adjusted hospital procedure rates for lower-extremity arterial bypass, peripheral angioplasty, and lower-extremity amputation (below-the-knee, above-the-knee, and through-the-foot procedures). Data are presented for an 18-year period, 1979 to 1996. This period began with the diffusion of increasingly distal bypass surgery techniques and the subsequent development of peripheral angioplasty.

To provide indirect estimates of changes in vascular disease prevalence, the National Center for Health Statistics' National Health Interview Survey (NHIS) estimates of trends in self-reported diabetes, ischemic heart disease, hypertension, and smoking for 1983 through 1994 were analyzed. These publicly available time series data on procedure rates and risk factors provide the first national estimate of progress in reducing the overall frequency of major lower-extremity amputation.

Methods

Data Sources

US population estimates of lower-extremity amputation, other vessel repair, and peripheral bypass surgery were obtained from 1979–1996 NHDS data tapes from the National Center for Health Statistics.[7] NHDS data are derived from a representative national sample of inpatient discharge records and provide weighted estimates of total discharges from short-stay, nonfederal hospitals. NHDS estimates are presented for 4 codes for femorodistal procedures listed in the *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*): for amputation through the foot (84.12), below the knee (84.15), and above the knee (84.17); for aorta-iliac-femoral bypass (39.25); and for

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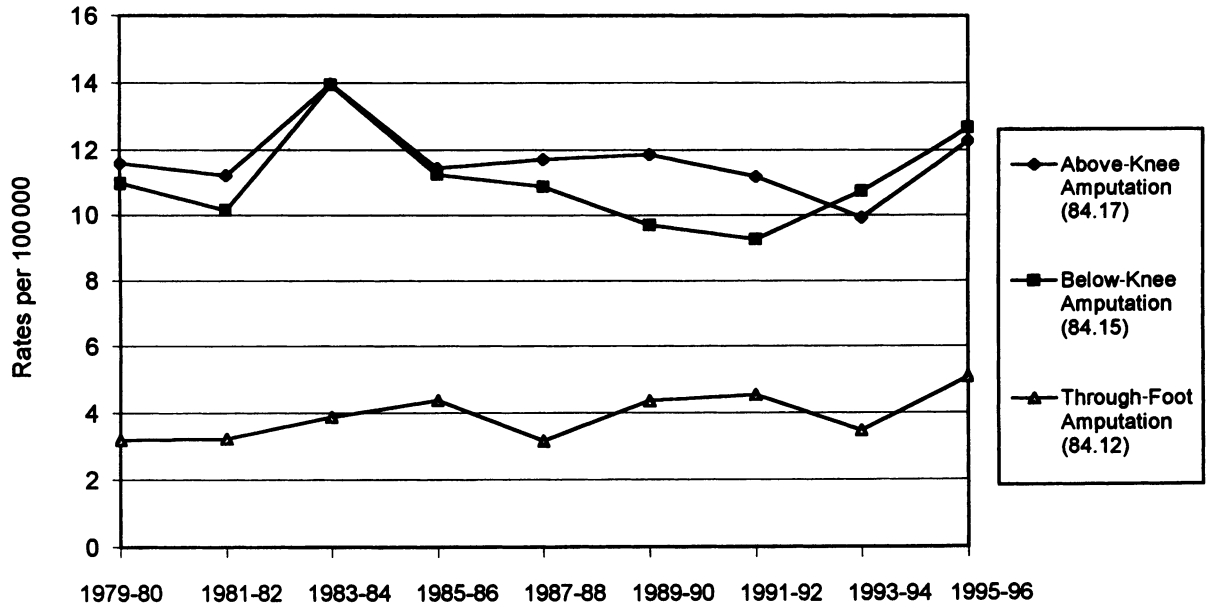


Note. Numbers after surgical procedures refer to codes listed in the *International Classification of Diseases, Ninth Revision, Clinical Modification.*
Source. National Hospital Discharge Survey.

FIGURE 1—Biannual lower-extremity amputation rates per 100 000, standardized to the 1990 US population.

other (peripheral) vascular shunt or bypass (39.29). To ensure that the analysis was based on patients with peripheral vascular disease or complications of diabetes, secondary diagnosis or procedure codes were used to exclude patients admitted for trauma or lower-extremity neoplasms or who underwent coronary artery surgery, carotid endarterectomy, or abdominal aortic aneurysm repair.

Estimates for lower-extremity angioplasty before 1995 are based on the other-repair-of-vessel code (39.59), which until that year was the *ICD-9-CM* code for lower-extremity angioplasty, and after 1995, on the explicit lower-extremity angioplasty code (39.50). To restrict this analysis to patients most likely to be undergoing angioplasty procedures for peripheral vascular disease, we excluded patients with codes for extracorporeal circulation or complications of dialysis catheter. The proportion of procedures with diagnosis codes related to peripheral vascular disease, atherosclerosis of the lower extremities, lower-extremity ulcers, gangrene, osteomyelitis of the lower limbs, or diabetes was estimated by following the methods used in the Maryland claims data study.[3–5]

Procedure rates were calculated on a biannual basis to reduce relative standard errors of the procedure estimates. An estimate of additional amputation procedures performed in Department of Veteran's Affairs hospitals (and therefore not included in the NHDS) was derived from published 1991 Veteran's Affairs Patient Treatment File statistics.[8] Finally, more recent NHDS discharge frequencies were checked against estimates from the nationally representative Hospital Cost and Utilization Project database of the Agency for Health Care and Policy Research.[9]

US population prevalence estimates of diabetes mellitus, ischemic heart disease, hypertension, and current smoking were obtained from NHIS Series 10 reports from the National Center for Health Statistics[10–21] for the years 1983 through 1994. The NHIS provides annual estimates of the prevalence of self-reported chronic conditions from approximately 120 000 household surveys of a representative sample of the civilian, noninstitutionalized population of the United States. Smoking prevalence estimates for 1984 through 1986, 1989, and 1994 were obtained by interpolating the means of the rates from adjacent years.

Annual NHDS estimates were adjusted to the US population according to 5 age groups (<44, 44–64, 65–74, 75–84, and ≥85 years). Annual rates per 100 000 were then directly standardized to the 1990 US population.[22] Annual NHIS estimates of prevalence rates per 1000 for diabetes, ischemic heart disease, hypertension, and smoking were adjusted for sex and 3 age categories (<45, 45–64, and ≥65 years) and directly standardized to the 1990 US population.

Statistical Analysis

The Mantel-Haenszel χ^2 test for linear trends in proportions was used to determine the significance of associations between year and both NHDS procedure rate and NHIS prevalence rate estimates.[23] Pearson correlation coefficients were computed to determine associations of 18-year trends in major (above- and below-the-knee) amputation rates and rates of lower-extremity bypass and other vessel repair, as well as 12-year correlations with heart disease, smoking, hypertension, and diabetes prevalence rates.

Results

Trends in Lower-Extremity Amputation Procedures

Figure 1 shows biannual NHDS estimates of lower-extremity amputation procedure rates per 100 000 people, age-adjusted to the 1990 US population. After increasing during the early 1980s, both above- and below-the-knee amputation rates underwent a downward trend until the early 1990s. However, by 1995 to 1996, combined rates for both procedures (12.28 and 12.65 per 100 000, respectively) were 10.6% above their combined 1979 to 1980 rates (11.06 and 10.09 per 100 000) and well above their

TABLE 1—Biannual Estimates of Major Amputation Rates per 100 000, Standardized to the 1990 US Population

Year	Above-Knee Amputations				Below-Knee Amputations			
	Males	Females	Age <65	Age ≥65	Males	Females	Age <65	Age ≥65
1979–1980	15.68	9.73	1.95	9.86	12.77	9.01	3.25	7.17
1981–1982	14.82	8.96	1.91	9.08	12.60	8.20	2.38	7.38
1983–1984	19.38	11.66	2.10	12.20	15.65	10.93	3.92	8.76
1985–1986	17.27	10.04	1.85	10.58	12.81	8.91	2.60	7.75
1987–1988	17.13	10.05	0.96	11.49	12.68	8.39	2.27	7.61
1989–1990	19.04	10.14	1.25	11.70	10.62	6.78	1.61	6.47
1991–1992	18.78	10.90	1.60	11.90	9.86	6.67	2.08	5.73
1993–1994	13.79	7.88	1.69	8.07	12.73	9.35	3.32	7.33
1995–1996	18.13	11.06	1.51	11.93	11.60	8.29	2.44	7.05
Annual Mean	17.11	10.05	1.65	10.76	12.37	8.50	2.65	7.25

Source. National Hospital Discharge Survey.

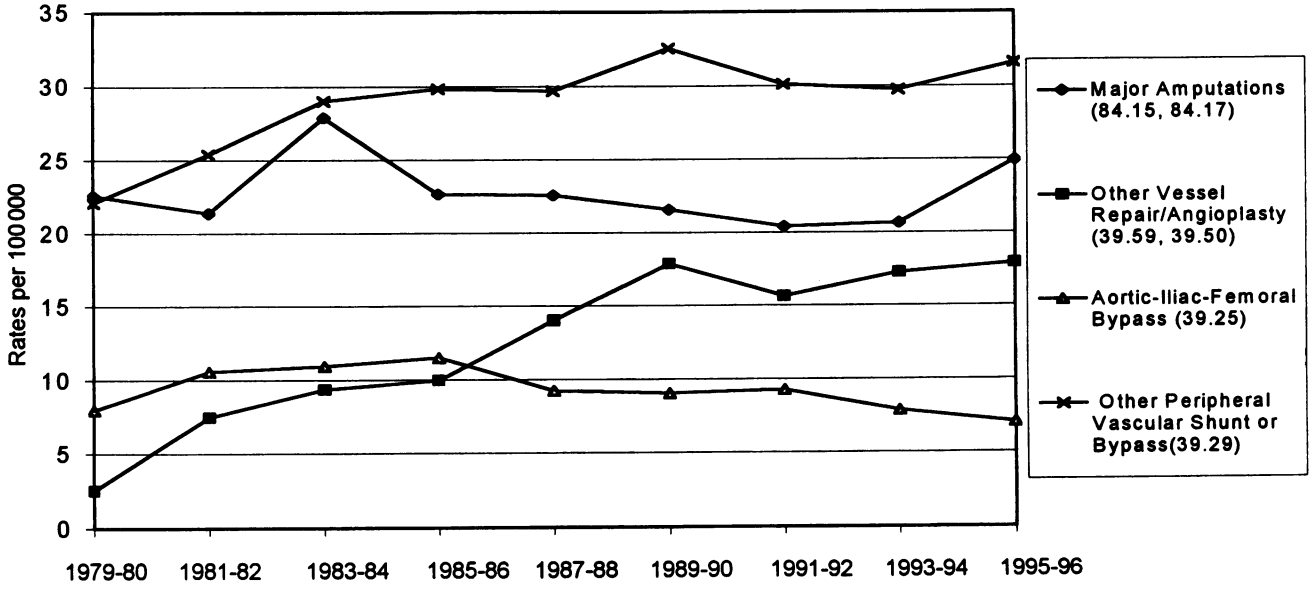
18-year mean rates (11.68 and 11.05 per 100 000). The mean annual incidence of major amputation (combined above- and below-the-knee) procedures over the study period was 54 072 (SD = 7808), an all-listed-procedures biannual estimate associated with an approximately 6% relative standard error.[7] While there were no significant linear trends for major amputation procedures, the rate of through-the-foot amputations increased 76%, from 4.00 per 100 000 in 1979/80 to 7.07 per 100 000 in 1995/96 ($P = .02$).

Table 1 presents NHDS estimates of rates per 100 000 of major amputation procedures for males and females and for patients younger than 65 years and 65 years and older. Males had a 70.2% higher mean above-the-knee amputation rate and a 45.5% higher below-the-knee amputation rate than females. Older patients had a mean above-the-knee rate 6.5 times higher than that of younger patients and a mean below-the-knee amputation rate 2.7 times higher than younger patients. No significant linear trends were found across the study period for these rates, which all increased from 1979/80 to 1995/96.

The NHDS estimate of major amputation procedure frequencies (above and below the knee) for 1992 (53 662) was about 3% below the estimate (55 462) reported from the nationally representative Hospital Cost and Utilization Project database for 1992.[9] Data from the Department of Veteran's Affairs Patient Treatment File for 1991[8] indicated that an additional 2376 above- and below-the-knee amputations were performed in that system, an approximate 4.4% increase over NHDS estimates.

Trends in Lower-Extremity Revascularization Procedures

Figure 2 displays estimates of rates per 100 000 of major lower-extremity amputation



Note. Numbers after surgical procedures refer to codes listed in the *International Classification of Diseases, Ninth Revision, Clinical Modification.*
Source. National Hospital Discharge Survey.

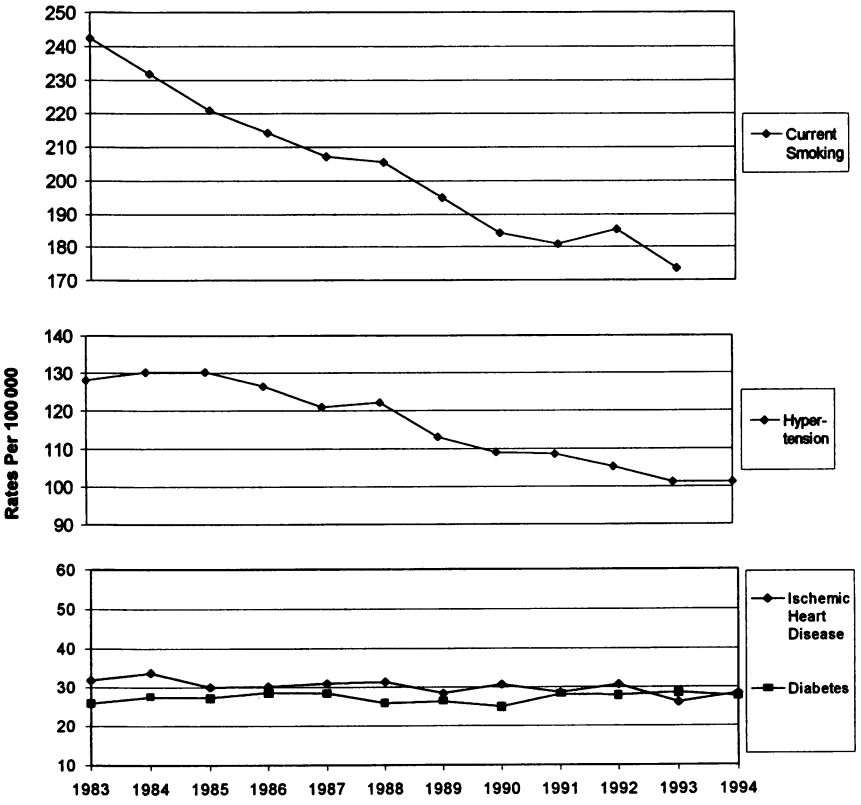
FIGURE 2—Biannual lower-extremity amputation, bypass surgery, and other vessel repair/angioplasty rates per 100 000, standardized to the 1990 US population.

(above- and below-the-knee rates combined, excluding foot procedures), other vessel repair, and lower-extremity bypass procedures, age adjusted to the 1990 population. Estimates of bypass surgery procedure rates are plotted separately for aorta-iliac-femoral procedures (*ICD-9-CM* code 39.25) and other, more distal bypass procedures (*ICD-9-CM* code 39.29).

As can be seen in Figure 1, major amputation rates declined during the mid-1980s only to increase again in the 1990s, with an estimated 73 717 major amputation procedures performed in 1996. Distal bypass rates increased significantly in the early 1980s and peaked in 1988 to 1989. There was an overall 43% increase in distal bypass rates, from 22.09 per 100 000 in 1979/80 to 31.54 per 100 000 in 1995/96 ($P = .005$). Rates of aorta-iliac-femoral procedures decreased 12.9% over the period, from 7.96 in 1979/80 to 7.05 in 1995/96 ($P = .06$). Other vessel repair rates were more than 7 times higher during this period, from 2.53 in 1979/80 to 17.90 in 1995/96 ($P < .001$). All of this increase in other vessel repair procedures occurred in the 1980s, with the rates leveling off in the 1990s, consistent with the creation of increased hospital capacity for peripheral angioplasty during that period.[13] Examination of secondary diagnosis codes revealed that approximately 95% of amputation procedures, 93% of distal bypasses, 88% of aorta-iliac-femoral bypasses, and 85% of other vessel repairs were related to indications of peripheral vascular disease or complications of diabetes.

Ischemic Heart Disease, Diabetes, Hypertension, and Smoking Prevalence Estimates

Figure 3 displays 1983/94 NHIS estimates of annual rates per 1000 of self-reported ischemic heart disease, diabetes, hypertension, and current smoking for 1983/94, age- and sex-adjusted to the 1990 population. Estimates for the prevalence of self-reported ischemic heart disease declined 11%, from a rate of 32.03 per 1000 in 1983 to 28.58 per 1000 in 1994 ($P = .02$), a contrast to larger, well-known declines in heart disease mortality rates over the same period. Annual diabetes prevalence estimates fluctuated between 25 per 1000 and 28 per 1000, with no significant linear trend ($P = .42$). Hypertension prevalence declined 21% over the 12 years, from 128.21 per 1000 in 1983 to 101.14 per 1000 in 1994 ($P = .001$). Current smoking declined 28%, from 242.49 per 1000 in 1983 to 173.65 per 1000 in 1993 ($P = .002$), the last year for which NHIS data were available.



Note. Smoking prevalence estimates for 1984, 1986, 1989, and 1994 were interpolated from adjacent years.

FIGURE 3—Self-reported rates of ischemic heart disease, hypertension, diabetes, and current smoking* per 1000, standardized to the 1990 US population.

Overall 12-Year Correlations With Major Amputation Rates

No significant bivariate correlations were found between the overall 18-year trend in major amputation rates and trends in bypass or other vessel repair procedures. However, when examining just the 12 years (1983–1994) with NHIS data, rates of smoking ($r = 0.88$, $P < .0001$), heart disease ($r = 0.73$, $P = .007$), and hypertension ($r = 0.65$, $P = .02$) were significantly correlated with amputation rates but not with diabetes (–0.33, $P = .29$). Most of the decline in amputation rates predated the increase in lower-extremity angioplasty after 1985 to 1986.

Conclusions

This study was undertaken to determine whether lower-extremity amputation rates have been declining in the United States during a period in which cardiovascular mortality was also declining and significant improvements were occurring in interventional treatment of limb-threatening ischemia and disabling claudication. The early 1980s saw the establishment of a special certification in general vascular surgery (1982), accumulated experience with bypasses beyond the popliteal artery to tibial and pedal vessels, and the development of lower-extremity balloon angioplasty.[24] By the 1990s, endovascular stents, thrombolytic therapy, newer imaging techniques, and improvements in antibiotics and primary foot care[8] became available to large numbers of vascular disease and diabetic patients. While these developments may have restrained growth in amputation rates for an aging US population, this study found no evidence that major amputation rates have decreased over the last decade.

Other studies have found that increases in lower-extremity revascularization procedures have led to lower amputation rates. Data from Denmark revealed a 28% overall decline in the per-population rate of lower-extremity amputation between 1983 and 1990.[25] During this period, there was a 100%

increase in the number of vascular procedures performed in Denmark, and there was a significant regional rank order correlation between the increase in infrainguinal reconstruction procedures and declines in major amputation. The Olmsted County, Minnesota, study also found an association between a tripling of distal bypass surgery and angioplasty rates after 1985 and reduced rates of major amputation.[6] This study suggests a complementary limb salvage role for angioplasty; there was no difference in the proportion of Olmsted County patients with critical leg ischemia who initially underwent bypass surgery vs angioplasty for femoropopliteal-tibial disease.

The findings presented here indicate that major amputation rates in the United States did decline significantly between their peak in 1983 to 1984 and low point in 1993 to 1994. This finding is consistent with a lagged effect of the dissemination of distal bypass procedures in the early 1980s and peripheral angioplasty in the late 1980s. This period also had the steepest declines in the self-reported prevalence of major cardiovascular risk factors such as smoking, hypertension, and ischemic heart disease. In 1988 to 1989, large increases in lower-extremity angioplasty procedures were accompanied by a temporary spike in the rate of femoropopliteal bypass procedures. After 1993 to 1994, major amputation rates increased significantly while distal revascularization procedures increased more modestly, consistent with relatively fixed hospital vascular surgery capacity.[26]

The most important predisposing risk factors for lower-extremity vascular disease are male sex, advanced age, smoking, coronary heart disease, diabetes, severe hypertension, and hyperlipidemia.[27] Using available national time series estimates, this study found significant reductions in the self-reported prevalence of smoking, hypertension, and heart disease and a steady prevalence of diabetes. These data are only one piece of a larger vascular disease incidence, prevalence, and survival model, and they may be at odds with some population study data based on clinical case ascertainment measures.[28] However, while risk factor reduction may be responsible for some of the reduction in amputation rates during the 1980s, key risk factors have continued their decline into the 1990s while the major amputation rate has leveled off. This undoubtedly reflects the complex relationship between changing atherosclerotic disease patterns and declining cardiovascular mortality rates among older Americans, many of whom may now be living long enough to develop peripheral vascular complications.

Several important methodological problems continue to limit interpretation of this and other studies of hospital claims data.[29] The foremost problem is obviously the lack of individual patient identifiers. NHDS estimates are at the procedure level rather than the patient level, and they therefore reflect the incidence of multiple procedures for the same patient. Ideally, medical records and death certificate data could be linked so as to determine amputation-free survival for patients undergoing arterial reconstruction. Such linked data could determine how well bypass procedures prevent or delay amputation and the extent to which primary amputation without prior revascularization is occurring. It is also difficult to use secondary diagnosis codes to ascertain changes in the use of bypass and angioplasty for disabling intermittent claudication as opposed to critical leg ischemia.[30,31]

Survival models of patients with coronary disease are now able to measure the relative contribution of treatment (medical intervention) and prevention (lowering risk factors among asymptomatic individuals).[32] The findings described here provide some initial parameters for a forecasting model eventually capable of estimating the relative effects of vascular disease treatment on amputation rates. Resolving the paradox of increasing amputation rates in the face of improved medical and surgical care will require a closer examination of the frequency and circumstances of primary amputation rates in the United States. □

Contributors

J. Feinglass, J. L. Brown, and W. H. Pearce conceived the study design. L. M. Manheim and M.-W. Sohn analyzed State of California discharge data used in an earlier draft and for validation of national estimates, as well as assisted in statistical analyses. J. L. Brown and S. J. Shah obtained initial published NHDS, NHIS, and US population data, performed literature reviews, and assisted in computing standardized rate calculations. A. LoSasso was responsible for data processing of computerized NHDS data. W. H. Pearce provided clinical oversight and expertise and J. Feinglass wrote the paper, with all authors providing comments and review.

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