Geographic Variation of Lower-Extremity Major Amputation in Individuals With and Without Diabetes in the Medicare Population

JAMES S. WROBEL, DPM[1]
JENNIFER A. MAYFIELD, MD[2]
GAYLE E. REIBER, PHD[3]

OBJECTIVE — To describe geographic variation in rates of lower-limb major amputation in Medicare patients with and without diabetes.

RESEARCH DESIGN AND METHODS — This cross-sectional population-based study used national fee-for-service Medicare claims from 1996 through 1997. The unit of analysis was 306 hospital referral regions (HRRs) representing health care markets for their respective tertiary medical centers. Numerators were calculated using nontraumatic major amputations and the diabetes code (250.x) for individuals with diabetes. Denominators for individuals with diabetes were created by multiplying the regional prevalence of diabetes (as determined using a 5% sample of Medicare Part B data identifying at least two visits with a diabetes code for 1995–1996) by the regional Medicare population. Denominators for individuals without diabetes were the remaining Medicare beneficiaries. Rates of major amputations were adjusted for age, sex, and race.

RESULTS — Rates of major amputations per year were 3.83 per 1,000 (95% CI 3.60–4.06) individuals with diabetes compared with 0.38 per 1,000 (95% CI 0.35–0.41) individuals without diabetes. Marked geographic variation was observed for individuals with and without diabetes; however, patterns were distinct between the two populations. Rates were high in the Southern and Atlantic states for individuals without diabetes. In contrast, rates for individuals with diabetes were widely varied. Variation across HRRs for individuals with diabetes was 8.6-fold compared with 6.7-fold in individuals without diabetes for major amputations.

CONCLUSIONS — Diabetes-related amputation rates exhibit high regional variation, even after age, sex, and race adjustment. Future work should be directed to exploring sources of this variation.

Diabetes Care 24:860–864, 2001

Geographic variation in the rates of surgical procedures has been described (1–7). Although variations in the rate of amputation of the lower limb for individuals with diabetes have been reported for The Netherlands (8), no such report has been described for the entire U.S. Consequently, we undertook this analysis to describe the major amputation rates in the Medicare population for individuals with and without diabetes.

RESEARCH DESIGN AND METHODS

As part of ongoing work with the Dartmouth Atlas of Health Care project, we analyzed claims data during hospitalizations for all nontraumatic lower-limb major amputations in individuals with and without diabetes enrolled in Medicare from 1996 through 1997 (6).

Numerators for nontraumatic amputations were selected from the MEDPAR file for 1996–1997. Numerators were calculated from hospital discharges using diabetes code (ICD-9-CM, code 250.x) and the highest-level amputation during the hospitalization. Major amputations were defined as transtibial (84.15) or transfemoral (84.17).

Denominators were calculated using the Medicare Denominator file (HISKEW) for 1996–1997. Denominators for individuals with diabetes were estimated by multiplying the regional prevalence of diabetes by the regional Medicare population. The regional prevalence of diabetes was based on HEDIS 3.0 using Medicare Part B claims data for 1995–1996. Patients with diabetes were defined by having a diagnosis code (ICD-9-DM 357.2x, 362.x, 648.0x, 250.xx, or 366.41) listed on at least two outpatient visits or one inpatient stay evaluation and management code (9,10). Denominators for individuals without diabetes were the remaining Medicare beneficiaries. To ensure that subjects counted in the numerator corresponded to the denominator, enrollees younger than 65 years of age or older than 99 years of age were excluded. Enrollees in risk-bearing health management organizations (~11% for 1996) were excluded from both the numerator and denominator (11).

The unit of analysis was the hospital referral region (HRR). The 306 HRRs represent health care markets for their re-

From the [1]Veterans Affairs (VA) Medical and Regional Office Center, White River Junction, Vermont, and the Department of Community and Family Medicine, Dartmouth Medical School, Hanover, New Hampshire; the [2]Center of Excellence in Amputation, Prosthetics, and Limb Loss Prevention, Rehabilitation Research and Development, VA Puget Sound Health Care System and the Department of Health Services, School of Public Health, University of Washington; and the [3]VA Puget Sound Health Care System and the Department of Health Services and Epidemiology, University of Washington, Seattle, Washington.

Address correspondence and reprint requests to James Wrobel, DPM, MS, VA White River Junction, Surgical Service #112, White River Junction, VT 05009. E-mail: james.s.wrobel@dartmouth.edu.

The opinions and views contained herein are the private views of the authors and are not to be construed as representing the views of the Health Care Financing Administration, Department of Veterans Affairs, or the U.S. Government.

Received for publication 5 October 2000 and accepted in revised form 16 January 2001.

Abbreviations: HRR, hospital referral region.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

spective tertiary medical centers. Individual regions were created by the zip codes in which a plurality of patients sought care. The average Medicare population for an HRR was 92,600; the smallest was 14,900 enrollees (6). Previous authors studied 11 surgical procedures and found 90% of the enrollees resided in the same HRR as the surgical center (7). Mapping of HRR boundaries by zip code was created using zip code boundary files from Geographic Data Technology (Lebanon, NH).

An indirect method was used to adjust procedure rates for sex, race (black, nonblack), and age (65–69, 70–74, 75–79, 80–84, 85+). To assess regional variation, the ratio from the highest to lowest HRR rates was calculated (7). HRRs with rates based on 10 or fewer procedures were dropped from the analysis to avoid unstable estimates of regional variation (7). For individuals without diabetes, two HRRs were dropped for major amputation.

Minor amputations (i.e., toe, ray resection, transmetatarsal, and Chopart's) were dropped from this analysis. We found 52,285 minor amputations in our analysis of 1996–1997 Part A data. A separate analysis of 1997 Part B data found 53,705 minor amputations. It seems that most minor amputations missed in Part A data were performed in individuals without diabetes. This is supported in our analyses, because 35 HRRs had to be dropped from the measure of extremal ratio and 80 HRRs were found to have rates >25% below the national average for minor amputation in individuals without diabetes. There will be future limitations in using Part B Medicare data for minor amputation in individuals with diabetes. Claims are limited to one diagnostic field and will likely yield low sensitivity for the diabetes diagnosis because minor amputations are performed for multiple diagnostic reasons (i.e., gangrene, osteomyelitis, septic arthritis, diabetes, etc.).

RESULTS — In the Medicare population during 1996 and 1997, a total of 44,599 and 39,111 major amputations were performed in individuals with and without diabetes, respectively. A total of 6,037,804 Medicare patients with diabetes were identified in 1996; there were 50,416,125 Medicare beneficiaries without the diabetes code in 1996. This resulted in a diabetes prevalence of 12% for the Medicare population in 1996. Patients with diabetes were 10 times more likely to undergo major amputation. The adjusted rate of major amputation for individuals with diabetes was 3.83 per 1,000 (95% CI 3.60–4.06) compared with 0.38 per 1,000 (95% CI 0.354–0.406; $P < 0.0000$) individuals without diabetes. The overall rate of major amputation was 3.69 per 1,000 patients with diabetes. For patients without diabetes, the overall rate was 0.39 per 1,000. Diabetes-related amputations accounted for 53% of major amputations.

Higher rates of major amputation for individuals without diabetes were observed in a wide path across the south, extending from North Carolina to Texas, and high rates were noted in the Mid-Atlantic states. However, in individuals with diabetes, the regions with the highest rates were more scattered, with pockets located in California, Texas, New Mexico, the upper Midwest, and the Mid-Atlantic states (Fig. 1 and Fig. 2).

Variation (the ratio from highest to lowest rate) across HRRs for individuals with diabetes was 8.6-fold compared with 6.7-fold in individuals without diabetes for major amputations (Table 1). The Pearson correlation coefficient was calculated for major amputation for individuals with diabetes to major amputation for individuals without diabetes and was found to be 0.56 (adjusted $R^2 = 0.31$).

CONCLUSIONS — Major amputation rates for individuals with diabetes exhibited 8.6-fold variation compared with 6.7-fold variation for major amputations for individuals without diabetes. Major amputation rates exhibited a high degree of variation when compared with 11 other procedures in the Medicare population over the same time period using the same methods. Only lower-extremity revascularization, carotid endarterectomy, back surgery, and radical prostatectomy exhibited higher variation than amputation in individuals with diabetes (7). In The Netherlands, rates of diabetes-related amputation for the 27 health care regions varied fourfold, whereas nondiabetes-related amputation varied only twofold (8). Our study found higher rates of variability than that observed in The Netherlands but a similar pattern of higher variability in individuals with diabetes as compared with individuals without diabetes.

Certain regions exhibited higher rates of major amputation in the Medicare population. For individuals without diabetes, higher rates were generally observed in the Southern and Atlantic states. However, for individuals with diabetes, higher rates of major amputation were much more varied.

Geographic variations in surgical care have been ascribed to population characteristics, underlying surgical capacity and lack of physician agreement on diagnostic or treatment modalities (12). We attempted to control for differences in the population characteristics by adjusting for age, sex, and race. Severity of disease and comorbid conditions may also affect rates of amputation. Previous authors using the same data set and methods found no change in rates of other procedures after the additional adjustment for comorbid conditions using modified Charlson scores (13). Other important population characteristics, such as education and socioeconomic factors, that may influence self-care and access to care (14–16) were not controlled because those data were not available.

Amputation rates may also be affected by lack of access to medical care. Common barriers include physical barriers of geography or transportation as well as financial and cultural issues. We have no evidence for geographic variation of these types of barriers.

Increased surgical capacity has also been shown to increase procedure rates (17). We have no data on geographic distribution of surgeons or providers of preventive foot care. For this reason, the HRR was selected as the unit of analysis in the present study because it is likely that most tertiary care facilities have a multidisciplinary foot clinic.

One of the more intriguing explanations for the differences in variability across regions involves regional differences in diagnosis and management, which develop when physicians do not agree on the best way to diagnose or manage a particular problem (6,7,18). This theory suggests that in the face of controversy and uncertainty, physicians develop a local culture or regional "practice style." For example, the rates of internal fixation of hip fracture exhibit little geographic variation, reflecting a straightforward diagnostic process and essentially one treatment option. In fact, the performance of internal fixation for hip fracture closely approximates the incidence of hip fracture in each population (7). On the other hand, radical prostatectomy for prostate cancer exhibits high regional variation,

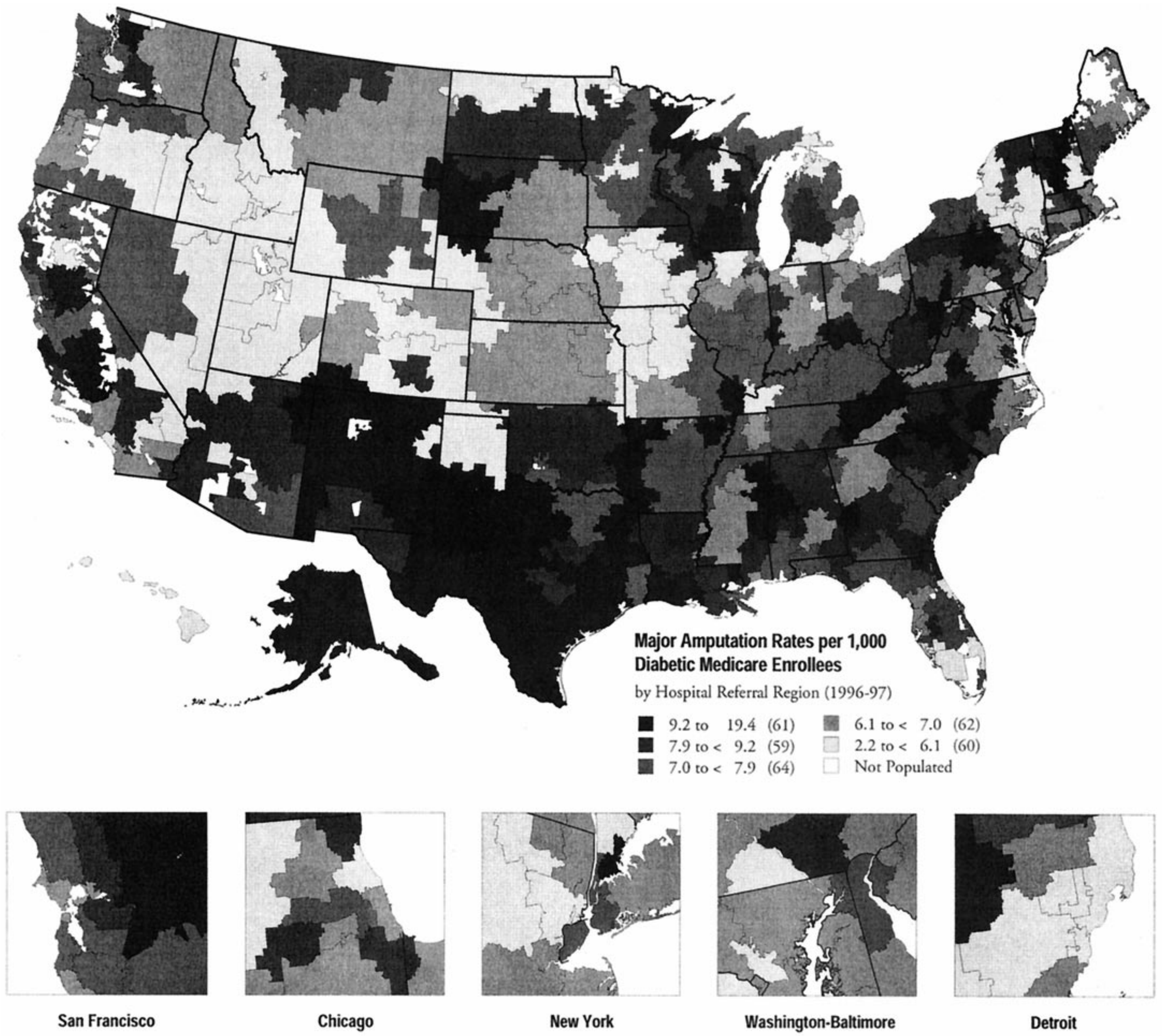

Figure 1—*Age-, sex-, and race-adjusted rates (number of HRRs by quintiles).*

reflecting the plethora of opinions on diagnostic and treatment strategies (7). We suspect that performance of major amputation, with its dire implications for disability and mortality, would be used only in extreme situations and would thus exhibit low regional variation. The correlation of 0.56 (adjusted $R^2 = 0.31$) suggests that within each region, major amputation decisions for diabetic and nondiabetic populations are influenced in a similar fashion.

The risk of amputation may be affected by management of risk factors leading to amputation. Preventive measures provided by multidisciplinary foot care teams implementing risk assessment, therapeutic foot wear, and patient education have demonstrated a 50–85% decreased risk of ulcer and amputation (19). Management of foot ulcers remains controversial, but effective management should include adequate assessment and treatment of infection, the use of debridement, and off-loading of weight during ambulation to increase the rate of ulcer healing and minimize amputation (20). Although there is significant disagreement regarding the most effective way to provide preventive care and ulcer management, there is currently no evidence for geographic variations in preventive foot care or ulcer management.

Peripheral vascular disease is the major cause of amputation in nondiabetic individuals and contributes to approximately half of all amputations in individuals with diabetes (21). Controversies regarding the appropriate assessment and management of peripheral vascular disease also exist. Although some centers of excellence have reported a decrease in amputation rates after aggressive surgical revascularization (22–24), population-based studies have found no change in

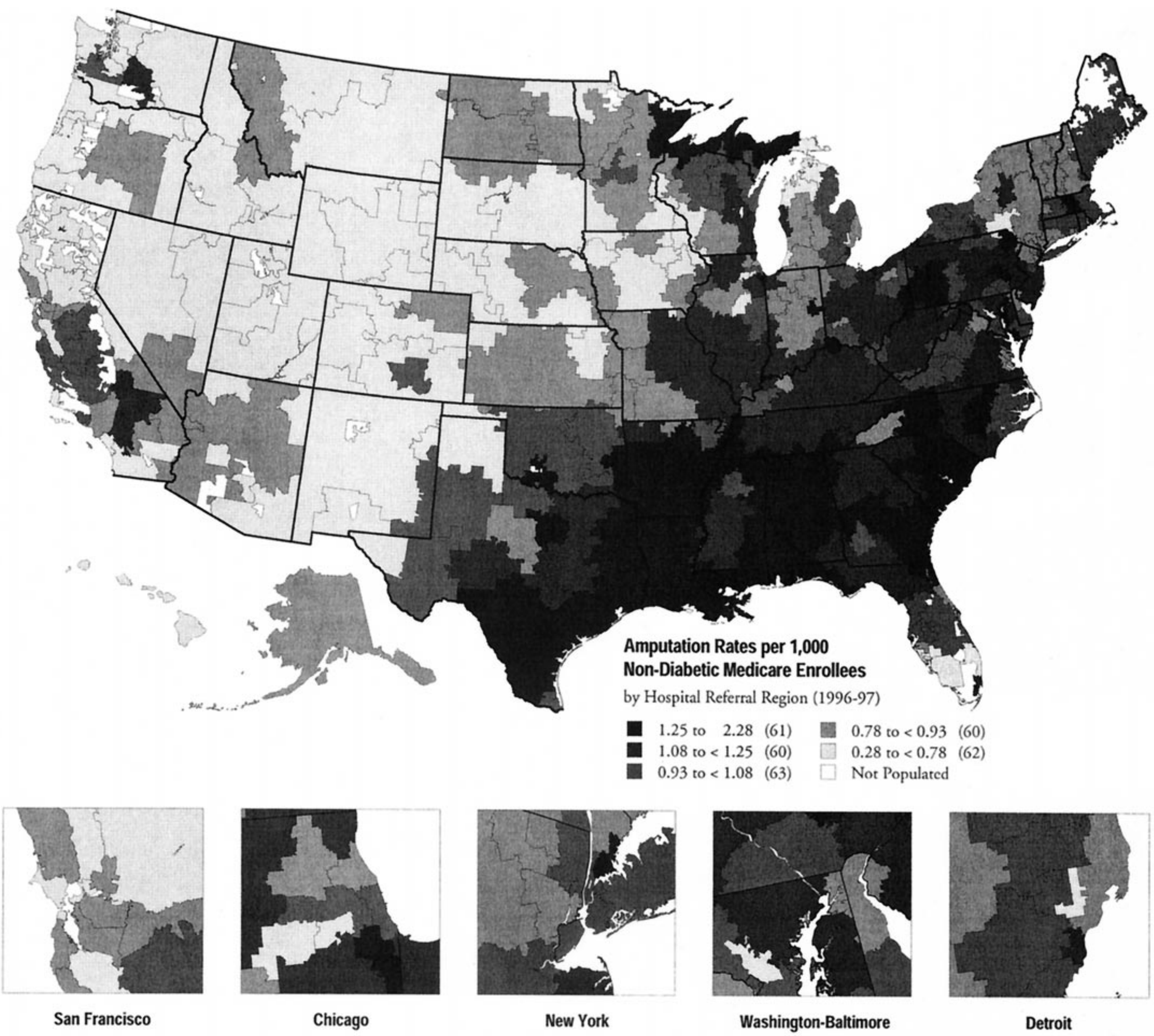

Figure 2—*Age-, sex-, and race-adjusted rates (number of HRRs by quintiles).*

amputation rates associated with a tripling of the vascular procedure rate (25,26). Interestingly, large geographical variations for lower-extremity vascular bypass procedure have also been described (6).

Our analysis has several potential limitations. Hispanic ethnicity is associated with lower rates of amputation in individuals with diabetes as compared with African-Americans or whites (16). We did not adjust for Hispanic ethnicity; we adjusted only for race by African-American status, which might overstate the amputation rate in regions with large Hispanic populations. Second, there may be some misclassification in ascertaining diabetes in the numerator and denominator. The sensitivity for the diabetes diagnosis in Medicare claims data has been reported to be 84% (95% CI 81–86%) when compared with chart audit (27). This same study reported that coding of major procedures had high sensitivity, ranging from 88 to 100%. A separate study reported that the diabetes diagnosis based on claims data in an ambulatory setting was

Table 1—*Measures of regional variation for major amputation*

	Diabetes	Nondiabetes
External ratio (highest to lowest region)	8.64	4.74
Number of regions with high and low rates		
Rates >25% below the national average	34	56
Rates >30% above the national average	42	28

sensitive (>70%), specific (>98%), and reliable ($\kappa > 0.80$) (28). That study used a method very similar to the present study. Also, estimates of the diabetes denominator in the present study compare quite favorably with other published studies (29).

Our analysis provides a glimmer of hope in reducing amputation rates. If there truly are differences in prevention and management that lead to amputation, these could be identified and adopted by other areas. If the rest of the country performed amputations at the 10th percentile rates of major amputation, there would be 6,299 fewer major amputations per year in Medicare patients with diabetes.

In summary, lower-limb amputation in individuals with and without diabetes exhibits high regional variation in the Medicare population, even after adjusting for the patient characteristics of age, sex, and race. We propose that this variation may be due to systematic differences in preventive care and treatment decision-making. Future work should explore regional variation in preventive care and identify the discretionary aspects of decision-making leading to amputation. Lastly, the observation that amputation rates are low in some areas suggests that care practices in those regions might be adopted on a widespread basis. This potential decrease in the amputation rate for the entire population should encourage public health officials, providers, and patients that there are indeed ways of decreasing the amputation risk for all diabetic individuals.

Acknowledgments— This work was supported in part by the Robert Wood Johnson Foundation and the Dartmouth Atlas of Health Care. G.E.R. was supported as a Career Scientist from the Veterans' Administration Health Services Research and Development Program (grant no. RCS 98353). G.E.R. and J.A.M. were also partially supported by the Rehabilitation Research and Development Center for Excellence in Amputation, Prosthetics, and Limb Loss Prevention of the Veterans' Administration (VA) Puget Sound Health Care System under the VA Rehabilitation Research and Development Program Grant no. A0806C.

We thank Sally Sharp and Janice Drexler for their help in data acquisition and John Birkmeyer and Jack Wennberg for their thoughtful suggestions and help with data acquisition.

References

1. Glover JA: The incidence of tonsillectomy in school children. *Proc R Soc Med* 31: 1219–1236, 1938
2. Lewis CE: Variations in the incidence of surgery. *N Engl J Med* 307:1310–1314, 1969
3. Wennberg JE, Gittlesohn A: Small area variations in health care delivery. *Science* 182:1102–1108, 1973
4. Chassin MR, Brook RH, Park RE: Variations in the use of medical and surgical services by the Medicare population. *N Engl J Med* 314:285–290, 1986
5. Gentleman JF, Vayda E, Parsons GF, Walsh MN: Surgical rates in subprovincial areas across Canada: rankings of 39 procedures in order of variation. *Can J Surg* 39:361–367, 1996
6. Wennberg JE, Cooper MM: *Dartmouth Atlas of Health Care*. Chicago, American Hospital Publishing, 1996
7. Birkmeyer JD, Sharp SM, Finlayson SRG, Fisher ES, Wennberg JE: Variation profiles of common surgical procedures. *Surgery* 124:917–923, 1998
8. Van Houtum WH, Lavery LA: Regional variation in the incidence of diabetes-related amputations in The Netherlands. *Diabetes Res Clin Pract* 31:125–132, 1996
9. National Committee for Quality Assurance: *Health Plan and Employer Data Information Set*. Version 3.0. Washington, DC, National Committee for Quality Assurance, 1998
10. National Committee for Quality Assurance: *HEDIS 3.0 Technical Specifications*. Washington, DC, National Committee for Quality Assurance, 1997
11. Buechner JS: Enrollment trends in Medicare managed care plans. *Med Health Rhode Island* 81:302–303, 1998
12. Wennberg, JE: Understanding geographic variations in health care delivery. *N Engl J Med* 340:52–53, 1999
13. Wennberg JE, Cooper MM: *Dartmouth Atlas of Health Care 1999: The Quality of Medical Care in the United States*. Chicago, IL, American Hospital Publishing, 1999
14. Reiber GE, Boyko EJ, Smith DG: Lower extremity foot ulcers and amputations in diabetes. In *Diabetes in America*. 2nd ed. Harris MI, Cowie CC, Stern MP, Boyko EJ, Reiber GE, Bennett PH, Eds. Washington, DC, U.S. Govt. Printing Office, 1995 (NIH publ. no. 95-1468)
15. Selby JV, Zhang D: Risk factors for lower extremity amputation in persons with diabetes. *Diabetes Care* 18:509–516, 1995
16. Lavery LA, Ashry HR, VonHoutum W, Pugh JA, Harkless LB, Basu S: Variation in the incidence and proportion of diabetes-related amputations in minorities. *Diabetes Care* 19:48–52, 1996
17. Lewis C: Variations in the incidence of surgery. *N Engl J Med* 307:1310–1314, 1969
18. Wennberg JE, Barnes BA, Zubkoff M: Professional uncertainty and the problem of supplier-induced demand. *Soc Sci Med* 16: 811–824, 1982
19. Mayfield JA, Reiber GE, Sanders LJ, Janisse D, Pogach LM: Preventive foot care in people with diabetes. *Diabetes Care* 21: 2161–2177, 1998
20. American Diabetes Association: Consensus development conference on diabetic foot wound care: 7–8 April 1999, Boston, Massachusetts. *Diabetes Care* 22:1354–1360, 1999
21. Pecoraro RE, Reiber GE, Burgess EM: Pathways to diabetic limb amputation: basis for prevention. *Diabetes Care* 13:513–521, 1990
22. Gibbons GW, Maracaccio EJ, Burgess AM, Pomposelli FB, Freeman DV, Campbell DR, Miller A, LoGerfo FW: Improved quality of diabetic foot care, 1984 vs 1990: reduced length of stay and costs, insufficient reimbursement. *Arch Surg* 128:576–581, 1993
23. LoGerfo FW, Gibbons GW, Pomposelli FB, Campbell DR, Miller A, Freeman DV, Quist WC: Trends in the care of the diabetic foot: expanded role of arterial reconstruction. *Arch Surg* 127:617–621, 1992
24. Rosenblum BI, Pomposelli FB, Giurini JM, Gibbons GW, Freeman DV, Chrzan JS, Campbell DR, Habershaw GM, LoGerfo FW: Maximizing foot salvage by a combined approach to foot ischemia and neuropathic ulceration in patients with diabetes: a 5-year experience. *Diabetes Care* 17:983–987, 1994
25. Tunis SR, Bass EB, Steinberg EP: The use of angioplasty, bypass surgery, and amputation in the management of peripheral vascular disease. *N Engl J Med* 325:556–563, 1991
26. Feinglass J, Brown JL, LoSasso A, Sohn MW, Manheim LM, Shah SJ, Pearce WH: Rates of lower extremity amputation and arterial reconstruction in the United States, 1979 to 1996. *Am J Public Health* 89:1222–1227, 1999
27. Fisher ES, Whaley FS, Krushat M, Malenka DJ, Fleming C, Baron JA, Hsia DC: The accuracy of Medicare's hospital claims data: progress has been made, but problems remain. *Am J Public Health* 82:243–248, 1992
28. Herbert PL, Geiss LS, Tierney EF, Engelgau MM, Yaw BP, McBean AM: Identifying persons with diabetes using Medicare claims data. *Am J Med Qual* 14:270–277, 1999
29. Centers for Disease Control and Prevention: The public health burden of Diabetes Mellitus in the United States. In *Diabetes Surveillance 1997*. Atlanta, GA, U.S. Department of Health and Human Services, Public Health Service, 1997