Lower-Extremity Amputation Risk Is Associated With Variation in Behavioral Risk Factor Surveillance System Responses

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EPIDEMIOLOGY/HEALTH SERVICES RESEARCH

OBJECTIVE

To determine whether regional variation in the rate of lower-extremity amputation (LEA) is associated with health behaviors.

RESEARCH DESIGN AND METHODS

This was a cross-sectional prevalence study of merged data from the U.S. Census, Medicare parts A and B, and the Behavioral Risk Factor Surveillance System. We used regression models to determine whether previously described regional variation in LEA incidence was associated with responses to the Behavioral Risk Factor Surveillance System. Regions were created using Dartmouth Atlas Health Referral Regions.

RESULTS

The mean and median incidence of LEA was 4.5 per 1,000 persons with diabetes; the rate varied from 2.4 to 7.9 LEA per 1,000 persons by health referral region. Statistically significant inverse associations were found between LEA and the rate of patients reporting colorectal screening ($P < 0.0001$) or the participation in diabetes management classes ($P = 0.018$). Most other factors, including daily foot evaluations, were not associated with a decreased risk of LEA. These findings were also found to be associated with geographically clustered regions known for increased risk of LEA.

CONCLUSIONS

LEA is known to vary by region in the U.S., and regions with higher rates of LEA tend to be clustered together. Some of this variation may be explained by health behaviors in those regions, such as attending diabetes education classes or better health prevention habits (e.g., colon cancer screening). It should be possible to prevent unwanted LEAs by educating individuals with diabetes and foot ulcers about the need for participation in foot ulcer treatment.

A poorly healing foot ulcer is a serious complication of diabetes that is estimated to occur in almost 25% of those persons with diabetes (1). Almost one-third of the $1.6 billion attributed to the care of persons with diabetes is linked to foot ulcers (1). Individuals with diabetes are at least 10 times more likely to undergo a lower-extremity amputation (LEA) than those without diabetes, and prior to undergoing an LEA 90% of patients with diabetes have a pre-existing foot ulcer (2). In the past 20 years, there have been ample discoveries about how wounds heal, but these

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innovations have not resulted in many new products to treat diabetic foot ulcers (3). Moreover, most therapies are difficult to use and, as noted in clinical trials, the overall rate of healing after several weeks of care has not substantially changed (4).

Several previous reports (5–8) have shown profound regional variation in the rate of LEA in individuals with diabetes. Variation exists both between countries and within a country. For example, there is an approximate twofold variation in the incidence of LEA between the U.K. and the U.S. (5,7). A study published in 2011 (5) in the U.S. demonstrated a nearly fourfold variation within the U.S. and further showed that increased incidence of LEA was clustered in contiguous regions within the U.S. This clustering persisted after adjustment for potential confounders (5). A similar study published in 2012 (9) noted that in the U.K. there was an eightfold variation between primary care trusts.

The reason for the geographic clustering of LEA is not apparent (8). It has long been known that regions closer together are more similar with respect to, for example, health care, education, and socioeconomic status than those that are farther apart. Regional variation in health behaviors could thus provide one explanation for the clustering of LEA (8). The Behavioral Risk Factor Surveillance System (BRFSS) provides an opportunity to investigate this issue. Established in 1984 by the Centers for Disease Control (CDC), the BRFSS was designed to monitor state-level prevalence of behavioral risks among adults associated with disease. This federally funded national survey is conducted by telephone and administered by the health departments of all 50 states. The survey includes core questions, optional modules, and state-specific questions designed to collect state-level core data on topics including current and potential health issues, and the prevalence of health risk behaviors. By merging the BRFSS data on health practices with Medicare data on LEA, the goal of our study was to examine whether behaviors related to the treatment of diabetic foot ulcers could explain geographic variability in the prevalence of LEA in the U.S.

RESEARCH DESIGN AND METHODS

This was a cross-sectional prevalence study conducted using the 306 hospital referral regions (HRRs) in the U.S. as the unit of analysis. HRRs, developed as part of the Dartmouth Atlas of Healthcare (www.dartmouthatlas.org), are often used to evaluate health care. We merged data at the HRR level from three data sources.

First, we accessed data from the BRFSS that we a priori thought might be of interest (Table 1) with respect to LEA. These reports were linked by ZIP code to HRRs. The BRFSS was established in 1984 by the CDC. It is the largest federally funded national phone survey. It is conducted in all 50 states and is administered by the health department in each state. The BRFSS surveys were designed to collect state-level core data on topics including current and potential health issues and the prevalence of health risk behavior. Each state selects the questions from those available from the CDC to administer. A full list of the BRFSS survey questions that we analyzed can be found in Table 1, and the regions where these questions were evaluated is displayed in Fig. 1. Our list of questions includes factors on social and emotional support, monthly consumption of alcohol, and colorectal cancer screening results, which may also be a marker of patient compliance with and understanding of diabetes care (10), as well as diabetes-specific questions concerning the following: frequency of health-care professional foot examination, frequency of foot self-examination, frequency of visits to a health-care professional for diabetes care, frequency of hemoglobin A_{1c} testing during the last 12 months, and participation in a diabetes education class. For this study, we used data collected in 2008.

Next, we merged data from Medicare parts A and B for beneficiaries from 2008 with continuous enrollment of at least 12 months. We previously reported on this cohort (5,11). This database includes information on LEA and uses the HRR as the unit of analysis. Information about this data set was summarized in several Data Points publications and a previous study (5,11,12).

Finally, we merged demographic data from the U.S. Census linked by ZIP code to HRR. This included race, age, gender, and socioeconomic status. The following HRR level variables for the geographic regions were based on year 2000 census data (data are available and in close proximity to the Centers for Medicare & Medicaid Services and BRFSS data): mean age, percentage African American, and percentage female. Our use of these data has also been described previously (5).

Statistical Analysis

As noted, our units of analysis were the HRRs. BRFSS data responses per 100 persons were calculated as means within HRRs after appropriate use of sampling weights. First, ordinary least squares (OLS) regression was used to examine how the prevalence of LEA varied as a function of each of the predictor variables of interest. Simple regression (unadjusted) was conducted for each predictor variable, followed by multiple regression that was fit using purposeful variable selection, the inclusion of variables with a P value of <0.10, and the maximization of R^2. We used conventional diagnostics including the Moran I test to assess for the presence of spatial autocorrelation. Finally, regression models were run using spatially weighted OLS regression. These multiple regression models were again fit based on purposeful variable selection, the inclusion of variables with a P value of <0.10, and the maximization of R^2. Based on our previous studies, we assumed a priori that in this study our data were potentially spatially autocorrelated. Standard diagnostics were used to determine the proper spatially weighted regression model, which for this study were consistently spatial error models. We also evaluated associations between the BRFSS questions and previously described areas that were known to be geospatially related with respect to an increased risk of LEA, decreased risk of LEA, and no geospatial correlation (5). This analysis used an ANOVA. Analyses were conducted using Stata version 12.1 (StataCorp LP, College Station, TX).

RESULTS

As noted above, the decision to include BRFSS survey questions in the yearly surveys was made by the state governments. There were a maximum of 306 HRRs, our unit of analysis. However, depending on the question, BRFSS data were available for between 94 and 71% of all HRRs (Table 1 and Fig. 1).

Table 1—BFRSS (adjusted for age, gender, and ethnicity/race)

BFRSS question	HRRs surveyed (*n*)	Simple regression	Spatial error regression	Fully adjusted regression
How often do you get the social and emotional support that you need? (always to sometimes)	289	−0.00052 (−0.0042 to 0.0032); 0.781	0.0049 (0.0048–0.005); ≤0.0001	0.0048 (0.0047–0.0050); ≤0.0001
Total alcoholic beverages consumed each month (*n*)	289	−0.0046 (−0.0080 to −0.0012); 0.009	−0.0033 (−0.0068 to 0.00022); 0.067	−0.00060 (−0.0041 to 0.0029); 0.733
Professional health check of feet in past 12 months (no)	218	−0.00048 (−0.0015 to 0.00057); 0.369	−0.00049 (−0.0015 to 0.00055); 0.355	−0.000094 (−0.0011 to 0.00087); 0.850
About how many times in the past 12 months have you seen a doctor, nurse, or other health professional for your diabetes? (not seen)	218	−0.0013 (−0.0028 to 0.00029); 0.110	−0.0013 (−0.0029 to 0.00025); 0.099	−0.00068 (−0.0021 to 0.00078); 0.358
Have you ever been told by a doctor or other health professional that you have prediabetes or borderline diabetes? (yes)	289	−0.0034 (−0.0087 to 0.0017); 0.189	−0.0040 (−0.0091 to 0.0011); 0.127	−0.0040 (−0.0088 to 0.00091); 0.111
Has your health professional checked your hemoglobin A_{1c} level in the past 12 months? (no)	218	−0.00045 (−0.0017 to 0.00077); 0.466	−0.00019 (−0.0014 to 0.0010); 0.768	0.00033 (−0.00080 to 0.0014); 0.565
Have you had a test for high blood glucose or diabetes in the past 3 years? (no)	289	0.00095 (−0.00014 to 0.0033); 0.424	0.00053 (−0.0018 to 0.0029); 0.662	0.00015 (−0.0021 to 0.0024); 0.895
About how often do you check your feet for any sores or irritations? (daily)	218	0.0015 (0.00047–0.0027); 0.005	0.00113 (0.00030–0.0025); 0.012	0.00082 (−0.00024 to 0.0019); 0.129
Have you taken a course or class in how to manage your diabetes yourself? (yes)	218	−0.0013 (−0.0024 to −0.0002); 0.018	−0.0010 (−0.0021 to 0.0001); 0.086	−0.0009 (−0.0019 to 0.0001); 0.051
Have you had a colorectal cancer screening? (yes)	289	−0.0028 (−0.0044 to −0.0023); <0.0001	−0.0027 (−0.0043 to −0.0011); 0.001	−0.0017 (−0.0032 to −0.00015); 0.031

Responses to queries are presented as regression coefficients (95% CIs); *P* values, with respect to their association with LEA.

Among the BRFSSs reporting HRRs, the mean and median incidence of LEA was 4.5 per 1,000 persons with diabetes, the rate varied from 2.4 to 7.9 LEAs per 1,000 persons with diabetes, and the measurement of spatial autocorrelation was statistically significant (Moran I test, $P < 0.0001$).

Both simple regression and multivariable spatial error models are presented in Table 1. The Moran I test for the BRFSS questions revealed *P* values that were not statistically significant (typically, $P = 0.2$ [i.e., no spatial correlation]). Further, the effect estimates (coefficients) for the BRFSS variables did not markedly change when the models included autocorrelation weights,

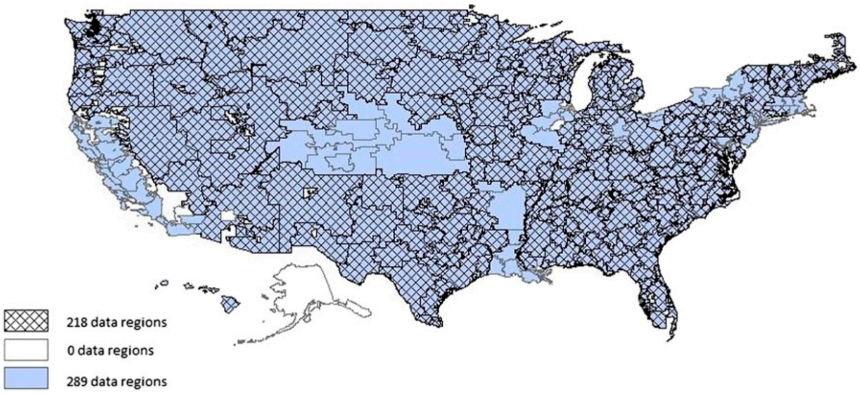

Figure 1—Distribution of HRR regions surveyed by specific BFRSS questions. Key: number of regions analyzed.

with the exception of a question on emotional support. The effect of the response to the emotional support question was inversely associated with amputation when analyzed using simple OLS regression and was associated with LEA when evaluated using a multivariate spatial autocorrelation model. Most BRFSS variables did not show statistically significant findings within our multivariate spatial autocorrelation regression models (Table 1). Interesting statistically significant inverse links were seen in that the incidence of LEA was lower in areas with a disproportionately high frequency of patients reporting colorectal screening (routine linear regression [unadjusted] $P < 0.0001$, multivariate regression with spatial correlation [fully adjusted] $P = 0.031$) and a high frequency of participation in diabetes management classes (unadjusted $P = 0.018$, fully adjusted $P = 0.050$). In contrast, conducting a daily patient foot examination was associated with an increased frequency of LEA (unadjusted $P = 0.005$, fully adjusted $P = 0.129$).

We next conducted an analysis by grouping HRRs into previously published geospatially based LEA risk categories, as follows: high rate of LEA, low rate of LEA, or no geospatial relationship (5). With this approach, daily foot examination was associated with residing in an HRR having a higher frequency of LEA ($P = 0.012$). Lower rates of diabetes education ($P = 0.01$), fewer hemoglobin A_{1c} screenings ($P = 0.01$), less diabetes care by health-care professionals ($P = 0.03$), and fewer colon cancer screenings ($P < 0.0001$) occurred in the geospatially linked higher LEA regions (Table 2).

CONCLUSIONS

In the U.S., profound regional variation in the incidence of LEA has been reported previously (5,8,13). Many explanations exist for this variation, but none have been confirmed (8). In this publication, we explored the variation in the rates of BRFSS health behaviors related to diabetes care. Areas where BRFSS participants noted more diabetes-based education also reported lower rates of LEA. Most dramatically, however, regional variation in colorectal cancer screening was associated with regional variation in LEA. Regions that had higher rates of LEA had lower rates of colon cancer screening. This phenomenon has been reported previously for other aspects of diabetes care and health care (10,14,15). We also consistently noted the minimal effect of patient foot self-examination on decreasing the rate of LEA. A similar observation was made previously in a group of patients treated in the Veterans Administration system (16,17).

Health literacy is broadly defined as the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions. Health literacy can include measures of print literacy, prose literacy, numeracy, and self-efficacy (18,19). Multiple studies have associated glycemic control as measured by hemoglobin A_{1c} with varying measures of patient health literacy, numeracy, and self-efficacy (20,21). In 2004, Rothman et al. (22) published a randomized clinical trial of an intensive disease management program aimed to improve glycemic control. In this fascinating study, those persons who received the intervention improved glycemic control as measured by hemoglobin A_{1c} levels. However, the effect was greatest when the intervention was administered to those of lower health literacy (22). Two U.S. cross-sectional studies found that those persons of low self-efficacy (for diabetes management) and poor numeracy (of diabetes) also had poor glycemic control as measured by hemoglobin A_{1c} level. A similar U.K. study also found poor numeracy (of diabetes) to be associated with poor glycemic control as measured by hemoglobin A_{1c} level (20–24). It is fair to conclude that interventions that improve patient comprehension of the need for glycemic control can improve glycemic control (21–23).

Few studies have investigated health literacy and LEA. A qualitative study by Feinglass et al. (25) of 26 patients who had recently undergone amputation, who did not all have diabetes, and were undergoing inpatient care in a Chicago rehabilitation facility provided some fascinating insights. Sixty-two percent of the patients had a very limited understanding of the association between the presence of a foot ulcer and amputation (25). Further, few patients understood why their prior treatment had failed, but 50% of patients noted

Table 2—Frequency of response with regions previously shown to be associated with clustered high association, low association, or no cluster association with LEA

Association	Emotional support	Alcoholic beverages	No foot check by a professional	No diabetes follow-up	A prediabetes diagnosis	No yearly hemoglobin A_{1c}	No screening glucose	Daily self-check of the foot	Diabetes education	Colon cancer screening	No yearly hemoglobin A_{1c}	No screening glucose
Unassociated	0.91 (0.03); 0.91	0.10 (0.03); 0.09	0.72 (0.11); 0.72	0.87 (0.08); 0.88	0.06 (0.02); 0.06	0.79 (0.10); 0.80	0.54 (0.05); 0.55	0.62 (0.11); 0.62	0.58 (0.12); 0.58	0.62 (0.06); 0.63	0.79 (0.10); 0.80	0.54 (0.05); 0.55
High association	0.89 (0.03); 0.89	0.09 (0.03); 0.08	0.65 (0.13); 0.70	0.83 (0.10); 0.85	0.07 (0.04); 0.06	0.74 (0.10); 0.75	0.56 (0.08); 0.55	0.68 (0.12); 0.68	0.50 (0.14); 0.50	0.56 (0.08); 0.55	0.74 (0.10); 0.75	0.56 (0.08); 0.55
Low association	0.90 (0.02); 0.89	0.10 (0.03); 0.10	0.70 (0.131); 0.67	0.85 (0.07); 0.86	0.06 (0.06); 0.06	0.82 (0.08); 0.80	0.55 (0.01); 0.55	0.62 (0.09); 0.60	0.59 (0.14); 0.59	0.64 (0.06); 0.65	0.82 (0.08); 0.80	0.55 (0.01); 0.55
P value*	0.01	0.14	0.03	0.03	0.703	0.01	0.535	0.012	0.01	<0.0001	0.01	0.535

Data are presented as the mean frequency (SD); median. For details, see Kantor and Margolis (4). Question titles are abbreviated from but are in the same order as in Table 1. *Based on within-column ANOVA.

trouble following their health-care provider's amputation prevention treatment recommendations, and they were surprised that LEA was associated with other disease (e.g., diabetes and peripheral vascular disease)-related comorbidities (25). The authors concluded that patients with low or marginal health literacy misunderstood the gravity of their medical history with respect to the onset of their LEA (25). To date, no studies have evaluated health literacy or its constituents in individuals with diabetes who were receiving care for foot ulcers.

Low health literacy, specifically with respect to diabetes care, can, however, be used to at least partially explain our findings. The treatment of diabetic foot ulceration is highly dependent on accessing health care, understanding the gravity of the relationship between having a foot ulcer and the loss of a lower limb, understanding and following treatment recommendations, and ultimately having the patient execute the treatment recommendations, which are often difficult for a patient to manage. A unifying explanation for our results might be that in regions of the country with higher medical literacy, as noted by a patient having obtained a colonoscopy and more diabetes education, there were fewer LEAs (10,14–17). With respect to colonoscopy and colon cancer screening, it has also been shown previously that those patients who have been screened are less likely to die even after adjustment for comorbidities (14,15). This association has been explained by the notion that those who receive appropriate screening are likely to be in health-care environments that favor better clinical judgment and better patient health behaviors (14,15). Both of these health-care attributes are also likely to diminish the risk of the development of a foot ulcer and/or undergoing an LEA. Further, it is possible that reporting daily foot self-examination and actually conducting a medically appropriate examination may not be equivalent or that those patients who conduct daily foot examinations do so because they have a critical foot disease, placing them at higher risk of LEA.

Like all studies of similar design, our study has limitations. Our LEA data are based on Medicare data, and the BRFSS data were from the general population. It is possible that within an HRR the responses of those who are eligible for Medicare and those who are not eligible for Medicare might differ. However, most LEAs occur in those patients with type 2 diabetes who are generally older and, most commonly, eligible for Medicare. Many of the BRFSS questions we used focused on those patients with diabetes or were questions that were most appropriate for those who were older (e.g., colon cancer screening); therefore, we feel that the BRFSS responses generalize to a Medicare population. Not all regions of the U.S. used the same BFRSS questions, but, as can be seen in Fig. 1, a vast percentage of the U.S. population was surveyed on our questions of interest. An additional limitation is that we compared population prevalence responses within HRRs and not individual responses. This is an important limitation, and future work should try to be based on individual responses and outcomes.

LEA varies in the U.S. by region, and regions with higher rates of LEA tend to be clustered together. We have shown that some of this variation may be explained by health behaviors in those regions where patients are more likely to attend diabetes education classes or are more likely to undergo colon cancer screening. It is important to realize that the most important risk factor for LEA is a pre-existing foot ulcer, and that treatments for foot ulcer are cumbersome and difficult for patients to use. It is likely that our results are consistent with the notion that patients who live in regions where the importance of health-care interventions is understood (i.e., patients have participated in diabetes education and understand the need for colon cancer screening) are likely to successfully participate in and use the care that is available for the treatment of a foot ulcer. To further test this hypothesis, it is important that future studies formally evaluate patient general health literacy and efficacy as well as diabetes-specific health literacy and efficacy with respect to diabetic foot ulcer care at the time that treatment is initiated. If this hypothesis is true, it should be possible to prevent unwanted LEAs by educating individuals with diabetes and foot ulcers about the need for proper foot care and participation in foot ulcer treatment, thereby diminishing the burden of this complication to both the individual with diabetes and the population at large (1).

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References

1. Armstrong DG, Kanda VA, Lavery LA, Marston W, Mills JL Sr, Boulton AJ. Mind the gap: disparity between research funding and costs of care for diabetic foot ulcers. Diabetes Care 2013;36:1815–1817
2. Markowitz JS, Gutterman EM, Magee G, Margolis DJ. Risk of amputation in patients with diabetic foot ulcers: a claims-based study. Wound Repair Regen 2006;14:11–17
3. Bennett SP, Griffiths GD, Schor AM, Leese GP, Schor SL. Growth factors in the treatment of diabetic foot ulcers. Br J Surg 2003;90:133–146
4. Kantor J, Margolis DJ. Expected healing rates for chronic wounds. Wounds 2000;12:155–158
5. Margolis DJ, Hoffstad O, Nafash J, et al. Location, location, location: geographic clustering of lower-extremity amputation among Medicare beneficiaries with diabetes. Diabetes Care 2011;34:2363–2367
6. Wrobel JS, Mayfield JA, Reiber GE. Geographic variation of lower-extremity major amputation in individuals with and without diabetes in the Medicare population. Diabetes Care 2001;24:860–864
7. Holman N, Young RJ, Jeffcoate WJ. Variation in the recorded incidence of amputation of the lower limb in England. Diabetologia 2012;55:1919–1925
8. Margolis DJ, Jeffcoate WJ. Epidemiology of foot ulceration and amputation: can global variation be explained? Med Clin North Am 2013;97:791–805
9. Holman KH, Henke PK, Dimick JB, Birkmeyer JD. Racial disparities in the use of revascularization before leg amputation in Medicare patients. J Vasc Surg 2011;54:420–426
10. Lewis JD, Capra AM, Achacoso NS, et al. Medical therapy for diabetes is associated with increased use of lower endoscopy. Pharmacoepidemiol Drug Saf 2007;16:1195–1202
11. Margolis D, Malay DS, Hoffstad OJ, et al. *Incidence of Diabetic Foot Ulcer and Lower Extremity Amputation Among Medicare Beneficiaries, 2006 to 2008*. Rockville, MD, Agency for Healthcare Research and Quality, 2010
12. Margolis D, Malay DS, Hoffstad OJ, et al. *Prevalence of Diabetes, Diabetic Foot Ulcer, and Lower Extremity Amputation Among Medicare*

Beneficiaries, 2006 to 2008. Rockville, MD, Agency for Healthcare Research and Quality, 2010
13. Jeffcoate WJ, Young B, Holman N. The variation in incidence of amputation throughout England. Pract Diabetes 2012;29:205–207
14. Synnestvedt MB, Weiner MG. Evaluation of the use of electronic health data to classify four-year mortality risk for older adults undergoing screening colonoscopies. AMIA Annu Symp Proc 2011;2011:1361–1365
15. Fisher DA, Galanko J, Dudley TK, Shaheen NJ. Impact of comorbidity on colorectal cancer screening in the veterans healthcare system. Clin Gastroenterol Hepatol 2007;5:991–996
16. Johnston MV, Pogach L, Rajan M, et al. Personal and treatment factors associated with foot self-care among veterans with diabetes. J Rehabil Res Dev 2006;43:227–238
17. Olson JM, Hogan MT, Pogach LM, Rajan M, Raugi GJ, Reiber GE. Foot care education and self management behaviors in diverse veterans with diabetes. Patient Prefer Adherence 2009;3:45–50
18. Nielson-Bohlman L, Panzer AM, Kindig DA (Eds.). *Health Literacy: A Prescription to End Confusion.* Washington, DC, National Academies Press, 2004
19. Paasche-Orlow MK, Wolf MS. Promoting health literacy research to reduce health disparities. J Health Commun 2010;15(Suppl. 2):34–41
20. Osborn CY, Cavanaugh K, Wallston KA, Rothman RL. Self-efficacy links health literacy and numeracy to glycemic control. J Health Commun 2010;15(Suppl. 2):146–158
21. Brega AG, Ang A, Vega W, et al.; Special Diabetes Program for Indians Healthy Heart Demonstration Project. Mechanisms underlying the relationship between health literacy and glycemic control in American Indians and Alaska Natives. Patient Educ Couns 2012;88:61–68
22. Rothman RL, DeWalt DA, Malone R, et al. Influence of patient literacy on the effectiveness of a primary care-based diabetes disease management program. JAMA 2004;292:1711–1716
23. Marden S, Thomas PW, Sheppard ZA, Knott J, Lueddeke J, Kerr D. Poor numeracy skills are associated with glycaemic control in Type 1 diabetes. Diabet Med 2012;29:662–669
24. Cavanaugh K, Huizinga MM, Wallston KA, et al. Association of numeracy and diabetes control. Ann Intern Med 2008;148:737–746
25. Feinglass J, Shively VP, Martin GJ, et al. How “preventable” are lower extremity amputations? A qualitative study of patient perceptions of precipitating factors. Disabil Rehabil 2012;34:2158–2165