The Relationship Between Provider Coordination and Diabetes-Related Foot Outcomes

Objective — To investigate the relationship between provider coordination and amputations in patients with diabetes.

Research Design and Methods — The study design was a cross-sectional, descriptive study of process and outcomes for diabetes-related foot care at 10 Department of Veterans Affairs (VA) medical centers representing different geographic regions, population densities, patient populations, and amputation rates. The subjects included all providers of diabetes foot care and a random sample of primary care providers at each medical center. The main outcome measures were the Foot Systems Assessment Tool (FootSAT), nontraumatic lower extremity amputation rates, and investigators’ ordinal ranking of site effectiveness based on site visits.

Results — The survey response rate was 48%. Scale reliability, as measured by Cronbach’s α, ranged from 0.73 to 0.93. The scale scores for programming coordination (i.e., electronic medical record, policies, reminders, protocols, and educational seminars) and feedback coordination (i.e., discharge planning, quality of care meetings, and curbside consultations) were negatively associated with amputation rates, suggesting centers with higher levels of coordination had lower amputation rates. Statistically significant associations were found for programming coordination with minor amputations (P = 0.02) and total amputations (P = 0.04).

Conclusions — The FootSAT demonstrated a stronger association with amputation rates than site visit rankings. Among these 10 VA facilities, those with higher levels of programming and feedback coordination had significantly lower amputation rates.

Diabetes Care 26:3042–3047, 2003

Diabetes-related foot complications result in an enormous patient burden. Patients with diabetes and foot ulcers are at risk for hospitalizations, lower extremity infections, and amputations (1,2). Both foot ulcers and amputations result in increased health care costs (3–6). Well-coordinated preventive foot care has been reported to reduce diabetes-related foot complications. A multidisciplinary diabetic foot clinic where treatment and footwear was provided to 239 patients with diabetes and foot ulcers demonstrated healing in 86% of neuropathic ulcers and 72% of ischemic ulcers. A 50% reduction in amputation rate was observed comparing rates before and after the program (7). Another study showed that a diabetes detection and control program that included an inpatient ward, outpatient clinics, and professional and patient teaching reduced amputation frequency ~50% compared with rates before the intervention. This reduction was sustained over several years (8). Research has demonstrated the relationship between provider coordination and patient outcomes in emergency room and intensive care unit settings (9–13). Building on general organizational theory (14–16), Charns and Schaefer (17) developed a conceptual framework that described coordination in two major categories: programming and feedback. Programming approaches depend on prespecifying activities to be performed and ensuring that staff have adequate training to perform these activities. Feedback approaches involve the exchange of information among staff to determine the activities to be performed and responsibilities for conducting these activities. Alt-White, Charns, and Strayer developed an instrument to assess coordination, specifically the use of programming and feedback modes of coordination, among health care professionals in acute care settings (18). They later reported a significant inverse relationship that showed that greater programming and feedback ap-
Development of the Foot Systems Assessment Tool

The Foot Systems Assessment Tool (FootSAT) was developed for this study to measure coordination. Previous work had identified programming and feedback as key domains of coordination in health care settings (11, 12, 19–21). The instrument used in previous work was modified for the FootSAT to include organizational processes for foot care. The modified instrument was pilot tested and underwent psychometric analyses before being used in a 10-site survey of VA foot care.

VA Study of Impact of Quality Improvement Intervention Upon Foot Care Outcomes

This study had two objectives. The first objective was to describe diabetes-related foot care across the spectrum of care from screening (i.e., foot exams) and surveillance (i.e., patient education, footwear, and nail and callus care) to limb salvage (e.g., ulcer management, vascular surgery, surgical restructuring, amputation, and rehabilitation). The second objective was to investigate the relationship between provider coordination and diabetes-related foot outcomes. We hypothesized that well-structured health care organizations with higher levels of communication and feedback would provide better foot care and have fewer lower extremity amputations.

RESEARCH DESIGN AND METHODS — This cross-sectional descriptive study described the system of diabetes-related foot care at 10 VA medical centers between 2000 and 2001. In the first of two phases, we conducted a provider survey (FootSAT) by mail coupled with a site visit where we interviewed foot and primary care providers at each medical center and computed amputation rates. In the second phase, we conducted a patient survey by mail, medical records abstraction, and a foot care cost analysis. This article describes research conducted in the first phase, the provider survey, and the site visits.

The unit of analysis was the medical center. We selected 10 VA medical centers from different regions of the country representing different patient populations, population densities, and high and low rates for nontraumatic diabetic lower limb amputations. Each medical center’s institutional review board approved the study protocol and procedures.

The local site principal investigator provided names and positions of all permanent staff involved with diabetes-related foot care. In addition, the principal investigators provided the names of primary care providers and medical center administrators to project staff who then confirmed the accuracy and completeness of each list. From this list, we selected general, vascular, and orthopedic surgeons; rehabilitation specialists; podiatrists; physical therapists; pedorthists; orthotists; diabetes care specialists; diabetesc educators; dermatologists; wound care specialists; and infectious disease physicians. In addition, select administrators and a random sample of 10 primary care providers were chosen at each site.

Provider survey

The FootSAT had four main constructs: programming coordination, feedback coordination, resources and information support, and perceived effectiveness of coordination modes. Scales for programming coordination and feedback coordination were used for the final FootSAT analysis as these constructs were based on a theoretical framework and demonstrated associations with patient outcome (9–21). Included in coordination strategies and communication strategies were programming coordination (10 items) and feedback coordination (29 items). All items in these two subscales used a closed question format, with a fixed set of choices that included a “not applicable” category to ensure that the range of possible responses was comprehensive. A group of clinical experts was convened to assess face validity of the instrument. The instrument was then modified to reflect their suggestions. Next, the modified instrument was pilot tested using a convenience sample of foot care providers from the investigators’ institutions; this process resulted in further modification. A complete version of the instrument can be found on the Diabetes Quality Enhancement Research Initiative website (http://www.va.gov/annarbor-hsr/queries/queries_projects.htm). The 10 programming coordination items were questions 1–10 in Section A; the 29 feedback coordination items were questions 11–16 in Section A and questions 1–23 in Section B.

The survey was mailed to providers at each of the 10 medical centers before a scheduled site visit. A self-addressed, postage-paid return envelope and a copy of the institutional review board’s approved informational statement explaining the study were enclosed with the survey. Participation was voluntary. A reminder letter was sent to all nonrespondents 3 weeks after the initial mailing. All identifiers were removed from survey responses once the data were entered, thus ensuring respondents’ anonymity.

Site visit ranking

Three research team members participated in the site visit to each medical center. Interviews were held with providers involved in diabetes-related foot care, including general, vascular, and orthopedic surgeons; rehabilitation specialists; podiatrists; physical therapists; pedorthists; orthotists; diabetes care specialists; diabetes educators; dermatologists; wound care specialists; and infectious disease physicians. In addition, select administrators and a random sample of primary care providers were interviewed. Site investigators followed structured interview protocols to obtain descriptive information regarding the local system of foot care for patients with diabetes. At the time of the site visit, investigators were blinded to the individual medical center’s amputation rates.

After each site visit, a summary report describing the local system of foot care was written. After all site visits had been completed, the investigative team met to review the system summaries and the strengths and weaknesses of each site. Investigators ranked the effectiveness of each medical center’s foot care program as high, medium, or low. An ordinal ranking of all sites was then created.

Amputation rates

Numerator were calculated from hospital discharges using a diabetes code (ICD-9-CM code 250.x) and the highest-level amputation during the hospitalization. Minor amputations were defined as toe or foot (ICD-9-CM 84.11–84.12). Major amputations were defined as transfemoral (ICD-9-CM 84.13–84.19). Denominators for individuals with diabetes were estimated from the VA Pa-
Table 1—Foot care process and outcome variables by site

<table>
<thead>
<tr>
<th>Site</th>
<th>n</th>
<th>Mean ± SD</th>
<th>Low</th>
<th>High</th>
<th>n</th>
<th>Mean ± SD</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>14</td>
<td>0.23 ± 1.46</td>
<td>-2.11</td>
<td>2.30</td>
<td>14</td>
<td>0.20 ± 1.45</td>
<td>-1.49</td>
<td>2.68</td>
</tr>
<tr>
<td>B</td>
<td>33</td>
<td>0.23 ± 0.94</td>
<td>-1.97</td>
<td>3.05</td>
<td>33</td>
<td>0.38 ± 1.15</td>
<td>-1.49</td>
<td>2.92</td>
</tr>
<tr>
<td>C</td>
<td>23</td>
<td>-0.1 ± 0.82</td>
<td>-1.44</td>
<td>1.46</td>
<td>23</td>
<td>-0.08 ± 0.85</td>
<td>-1.49</td>
<td>1.40</td>
</tr>
<tr>
<td>D</td>
<td>16</td>
<td>-0.19 ± 0.95</td>
<td>-1.13</td>
<td>1.77</td>
<td>16</td>
<td>-0.32 ± 1.15</td>
<td>-1.29</td>
<td>2.20</td>
</tr>
<tr>
<td>E</td>
<td>16</td>
<td>-0.42 ± 1.02</td>
<td>-0.99</td>
<td>2.00</td>
<td>16</td>
<td>-0.13 ± 0.77</td>
<td>-1.03</td>
<td>1.99</td>
</tr>
<tr>
<td>F</td>
<td>24</td>
<td>-0.48 ± 0.98</td>
<td>-2.11</td>
<td>1.15</td>
<td>24</td>
<td>-0.19 ± 0.83</td>
<td>-1.33</td>
<td>1.78</td>
</tr>
<tr>
<td>G</td>
<td>11</td>
<td>-0.08 ± 0.86</td>
<td>-1.13</td>
<td>1.36</td>
<td>11</td>
<td>-0.36 ± 1.06</td>
<td>-1.26</td>
<td>1.54</td>
</tr>
<tr>
<td>H</td>
<td>10</td>
<td>-0.02 ± 0.55</td>
<td>-0.80</td>
<td>0.94</td>
<td>10</td>
<td>-0.37 ± 0.49</td>
<td>-1.19</td>
<td>0.14</td>
</tr>
<tr>
<td>I</td>
<td>21</td>
<td>-0.45 ± 0.76</td>
<td>-1.75</td>
<td>1.18</td>
<td>21</td>
<td>-0.43 ± 0.74</td>
<td>-1.49</td>
<td>1.43</td>
</tr>
<tr>
<td>J</td>
<td>20</td>
<td>0.10 ± 1.19</td>
<td>-2.11</td>
<td>1.95</td>
<td>20</td>
<td>-0.17 ± 0.94</td>
<td>-1.49</td>
<td>2.57</td>
</tr>
<tr>
<td>Total</td>
<td>188</td>
<td>0 ± 1</td>
<td>-2.11</td>
<td>3.05</td>
<td>188</td>
<td>0 ± 1</td>
<td>-1.49</td>
<td>2.92</td>
</tr>
</tbody>
</table>

Foot care process and outcome variables by site

<table>
<thead>
<tr>
<th>Site</th>
<th>Programming coordination subscale score</th>
<th>Feedback coordination subscale score</th>
<th>Foot care effectiveness (1 = best, 10 = worst)</th>
<th>Outcome variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Programming coordination subscale score</td>
<td>Feedback coordination subscale score</td>
<td>Foot care effectiveness (1 = best, 10 = worst)</td>
<td>Lower extremity amputation rates/1,000</td>
</tr>
<tr>
<td></td>
<td>Major</td>
<td>Minor</td>
<td>Total</td>
<td>Major</td>
</tr>
<tr>
<td>A</td>
<td>2.04 (6/2946)</td>
<td>3.39 (10/2946)</td>
<td>5.43 (16/2946)</td>
<td>2.11 3.05 5.38 (172/60,748)</td>
</tr>
<tr>
<td>B</td>
<td>3.08 (43/13,981)</td>
<td>1.14 (16/13,981)</td>
<td>4.22 (59/13,981)</td>
<td>2.11 3.05 5.38 (172/60,748)</td>
</tr>
<tr>
<td>C</td>
<td>1.98 (7/3531)</td>
<td>1.70 (6/3531)</td>
<td>3.68 (13/3531)</td>
<td>2.11 3.05 5.38 (172/60,748)</td>
</tr>
<tr>
<td>D</td>
<td>3.51 (22/7875)</td>
<td>1.71 (15/7875)</td>
<td>4.22 (37/7875)</td>
<td>2.11 3.05 5.38 (172/60,748)</td>
</tr>
<tr>
<td>E</td>
<td>1.04 (5/4799)</td>
<td>1.25 (6/4799)</td>
<td>2.29 (11/4799)</td>
<td>2.11 3.05 5.38 (172/60,748)</td>
</tr>
<tr>
<td>F</td>
<td>3.40 (16/4710)</td>
<td>6.58 (31/4710)</td>
<td>9.98 (47/4710)</td>
<td>2.11 3.05 5.38 (172/60,748)</td>
</tr>
<tr>
<td>G</td>
<td>3.13 (14/4466)</td>
<td>3.81 (17/4466)</td>
<td>6.94 (31/4466)</td>
<td>2.11 3.05 5.38 (172/60,748)</td>
</tr>
<tr>
<td>H</td>
<td>3.93 (18/4582)</td>
<td>2.62 (12/4582)</td>
<td>6.55 (30/4582)</td>
<td>2.11 3.05 5.38 (172/60,748)</td>
</tr>
<tr>
<td>I</td>
<td>1.69 (8/4732)</td>
<td>3.17 (15/4732)</td>
<td>4.86 (23/4732)</td>
<td>2.11 3.05 5.38 (172/60,748)</td>
</tr>
<tr>
<td>J</td>
<td>4.01 (33/8226)</td>
<td>3.28 (27/8226)</td>
<td>7.29 (60/8226)</td>
<td>2.11 3.05 5.38 (172/60,748)</td>
</tr>
</tbody>
</table>

Analysis

The number of items in the survey was large relative to the number of respondents. To reduce dimensionality, we performed principal components analysis and developed a single index to represent each set of variables, which was applicable to more subjects. We compared the new reduced index with only the smaller set of items in a particular construct correlated well for use in group-level analyses. To perform the medical center-level analyses, we computed the mean of the individual-level FootSAT scores for each site. We then correlated and plotted these means against and plotted them in the overall site visit ranking of medical centers. We then calculated the mean for each subscale to ensure that the overall site score was averaged and the overall site visit ranking of medical centers.

RESULTS — The overall survey response rate for providers was 48% (1,883/3,957), with response rates among medical centers ranging 28–64%. FootSAT scale scores correlated against and plotted these means against and plotted them in the overall site visit ranking of medical centers.

The number of items in the survey was large relative to the number of respondents. To reduce dimensionality, we performed principal components analysis and developed a single index to represent each set of variables, which was applicable to more subjects. We compared the new reduced index with only the smaller set of items in a particular construct correlated well for use in group-level analyses. To perform the medical center-level analyses, we computed the mean of the individual-level FootSAT scores for each site. We then correlated and plotted these means against and plotted them in the overall site visit ranking of medical centers. We then calculated the mean for each subscale to ensure that the overall site score was averaged and the overall site visit ranking of medical centers.

The number of items in the survey was large relative to the number of respondents. To reduce dimensionality, we performed principal components analysis and developed a single index to represent each set of variables, which was applicable to more subjects. We compared the new reduced index with only the smaller set of items in a particular construct correlated well for use in group-level analyses. To perform the medical center-level analyses, we computed the mean of the individual-level FootSAT scores for each site. We then correlated and plotted these means against and plotted them in the overall site visit ranking of medical centers. We then calculated the mean for each subscale to ensure that the overall site score was averaged and the overall site visit ranking of medical centers.
reliability, as measured by Cronbach’s α, ranged from 0.73 for programming coordination to 0.93 for feedback coordination. All items in a particular scale correlated positively with the scale.

Table 1 displays foot care process and outcome data for each site. This includes FootSAT scores, site visit ordinal rankings, and amputation rates. Table 2 displays the correlations of the FootSAT subscales and site visit rankings with major, minor, and total amputations. As was expected, the scale scores for programming coordination and feedback coordination were negatively associated with amputation rates. Statistically significant associations were found for programming coordination with minor amputations \((P = 0.02)\) and total amputations \((P = 0.04)\) using a two-tailed test. Data for the two statistically significant relations are plotted in Figs. 1 and 2, which demonstrate that the association is not attributable to a single outlier.

**CONCLUSIONS** — To our knowledge, this is the first study describing the use of a systems assessment tool to illustrate significant associations between facility-level foot care program coordination, as assessed through survey of key foot care providers and rates of diabetes-related lower extremity amputations. We observed that associations between the FootSAT and outcomes were stronger than the site visit ordinal rankings and slightly larger in magnitude than the two facility-level process measures of foot screening activity and referral to specialists for high-risk foot care.

The strongest statistical association found was between programming coordination and amputation rates. Both programming and feedback modes of coordination were related to amputation rates in the hypothesized direction. The lack of a statistically significant relationship between feedback and amputations could be attributable to the low variance in this measure among study sites, as all sites were characterized by low levels of feedback modes of coordination.

The association between the site visit ordinal rankings and amputations did not reach statistical significance, although a prior study (25) found that patients tend to report better health status and under-report chronic diseases in a phone interview versus a mailed instrument such as the FootSAT. It is possible that in-person interviewees depicted their medical centers in a more favorable light than respondents to the mailed FootSAT or that the relatively small number of sites limited statistical associations.

The FootSAT demonstrated good reliability as measured by internal consistency of the items in a particular scale. All scales demonstrated Cronbach α coefficients >0.70, which is suggested for group-level analysis (26). All items in a particular scale correlated positively with the scale.

The FootSAT demonstrated validity for the purpose it was constructed. First, the instrument correlated in the expected direction with amputations; namely, there were statistically significant negative correlations with programming coordination and minor and total amputation rates. Second, the site visit ordinal rankings demonstrated negative correlations with the FootSAT.

These findings are consistent with the previously reported findings in the literature that have found associations between coordination and patient outcomes (9,20,21,27). Specifically, they provide further support for the relationship be-
Coordination and diabetic foot outcomes

Figure 2—Linear regression of total amputation rate by programming coordination for each center.

tween coordination and directly measured objective outcome measures, such as those previously reported for risk-adjusted surgical outcomes (19–21).

There was one potential limitation to these analyses. We found that the principal component method was robust to additions or deletions of items and that all items were correlated in the appropriate ways. However, it is possible that within some sites the indexes would be less appropriate. We also did not use adjustments for multiple comparisons.

Medical centers using higher levels of programming coordination had significantly lower amputation rates. These significant findings, even with a small number of facilities (n = 10), demonstrate the strength of the relationship. Organizations hoping to minimize their patients’ diabetes-related amputation rates should emphasize coordination of the delivery of foot care to diabetic patients. The FootSAT demonstrated a stronger association with amputation rates than site visit rankings or medical center–level process measures.

Acknowledgments—This research was supported by Health Services Research and Development, Department of Veterans Affairs, National Diabetes Data Group, Eds. Washington, DC, U.S. Govt. Printing Office, 1995, p. 485–500.

References


18. Alt-White A, Charns MP, Strayer RG: Personal, organizational, and managerial...
factors affecting nurse-physician collaboration. *Nurs Adm Q* 8:8–18, 1983