The Association Between Geographic Density of Infectious Disease Physicians and Limb Preservation in Patients With Diabetic Foot Ulcers

Meghan B. Brennan,1,2 Glenn O. Allen,3 Patrick D. Ferguson,4 Joseph A. McBride,1 Christopher J. Crnich,1,2 and Maureen A. Smith2

Department of Medicine, University of Wisconsin-Madison; Health Innovation Program, University of Wisconsin-Madison

Background. Avoiding major (above-ankle) amputation in patients with diabetic foot ulcers is best accomplished by multidisciplinary care teams with access to infectious disease specialists. However, access to infectious disease physicians is partially influenced by geography. We assessed the effect of living in a hospital referral region with a high geographic density of infectious disease physicians on major amputation for patients with diabetic foot ulcers. We studied geographic density, rather than infectious disease consultation, to capture both the direct and indirect (eg, informal consultation) effects of access to these providers on major amputation.

Methods. We used a national retrospective cohort of 56,440 Medicare enrollees with incident diabetic foot ulcers. Cox proportional hazard models were used to assess the relationship between infectious disease physician density and major amputation, while controlling for patient demographics, comorbidities, and ulcer severity.

Results. Living in hospital referral regions with high geographic density of infectious disease physicians was associated with a reduced risk of major amputation after controlling for demographics, comorbidities, and ulcer severity (hazard ratio, 0.83; 95% confidence interval, 0.75–0.91; P < .001). The relationship between the geographic density of infectious disease physicians and major amputation was not different based on ulcer severity and was maintained when adjusting for socioeconomic factors and modeling amputation-free survival.

Conclusions. Infectious disease physicians may play an important role in limb salvage. Future studies should explore whether improved access to infectious disease physicians results in fewer major amputations.

Keywords. geographic variation; infectious disease providers; major amputation; multidisciplinary teams.
PATIENTS AND METHODS

Data Sources
We used a 5% random national sample of Medicare beneficiaries from January 1, 2004 to December 31, 2011, obtained through the Centers for Medicare and Medicaid Services Chronic Condition Data Warehouse. Medicare enrollment and claims data were linked by patients’ 5-digit ZIP code of residence to hospital referral regions (HRRs), obtained through the Dartmouth Atlas [20]. Hospital referral regions represent the regional catchment areas for tertiary medical care provided at major referral centers. Each of the 306 HRRs contains at least 1 city where both major cardiovascular surgery and neurosurgery are performed. For the year 2006, the total number of Medicare enrollees in each HRR was obtained from the Centers for Medicare and Medicaid Services and the Dartmouth Atlas, which make the data publicly available [21]. The total number of practicing infectious disease physicians in 2006 and their 5-digit ZIP codes were obtained from the American Medical Association, allowing specialists to be assigned to a hospital referral region. Rural/urban commuting area (RUCA) codes, made publicly available through the Rural Health Research Center, were assigned to each patient using their 5-digit ZIP codes [22]. The RUCA codes represent rural/urban gradients of ZIP codes categorized as urban core, suburban, large town, small town, or isolated rural areas [23].

Study Design
We identified a retrospective, national rolling cohort of Medicare beneficiaries who were diagnosed with incident diabetic foot ulcer between January 1, 2006 and December 31, 2011 [24]. Diabetic foot ulcers were categorized as early stage, osteomyelitis, or gangrene (International Classification of Diseases, 9th Revision [ICD-9] codes are listed in the Appendix). Additional inclusion criteria were as follows: age ≥65 years at the time of ulceration, continuous Medicare parts A and B coverage during the 2-year baseline period before ulceration, and known to have diabetes during the baseline period [25]. Patients were identified as having diabetes if they had at least 1 inpatient or skilled nursing facility claim or more than 1 professional service claim in 24 months for the following ICD-9 codes: 250.xx, 357.2, 362.0x, 366.41, or 648.0x [25]. Patients were excluded if they were diagnosed with a foot ulcer or underwent major amputation during the baseline; this was to identify a population with incident diabetic foot ulcers, because most ulcerations that relapse do so within 2 years [26]. Railroad retirement beneficiaries, those with missing ZIP codes, and patients residing in US territories were also excluded. Patients were followed from the date of diabetic foot ulcer diagnosis until major amputation, death, loss of Medicare parts A and B coverage, or the end of the study period (December 31, 2011).

Primary Outcome
The time to major amputation was measured as the number of days from ulcer diagnosis to major amputation. The ICD-9 procedure codes and the following current procedural terminology codes were used to identify patients with major amputations: 27880, 27881, 27882, 27886, 27888, 27295, 27590, 27591, 27592, 27596, and 27598 [24, 27].

Primary Explanatory Variable
The geographic density of infectious disease specialists was calculated as the number of infectious disease physicians per 10000 Medicare enrollees in a patient’s HRR. The HRRs were then dichotomized into those above (high) and below (low) the median density of infectious disease physicians. The median, rather than the mean, was used because the distribution of infectious disease physician density was skewed to the right.

Covariates
Covariates were determined at the time of incident foot ulcer diagnosis. These included patient age, sex, race, ulcer severity at presentation (early stage, osteomyelitis, or gangrene), presence of uncomplicated diabetes, and prior myocardial infarction, ischemic heart disease, stroke, or eye disease [24, 27, 28]. The ICD-9 codes used to identify covariates are listed in the Appendix. Patient were considered engaged if they saw a primary care provider at least twice during the 2-year baseline period. The urbanicity of patients’ primary residence was characterized using RUCA codes.

Statistical Analysis
We described patient sociodemographics, ulcer severity, comorbid conditions, healthcare engagement, and reason for censoring both overall and stratified by low and high infectious disease physician density. We identified and mapped HRR outliers, areas with very high or low densities of infectious disease physicians, by the blocked adaptive computationally efficient outlier nominators algorithm [29]. This iterative method detected outliers by starting with a small subset of HRRs assumed not to contain outliers and then steadily increasing the subset. Each time an HRR was added, the difference between that single HRR’s geographic density of infectious disease physicians and the standard deviation of infectious disease physician density for the growing subset population was calculated. The HRRs with the largest absolute differences were identified as outliers.

We used Cox proportional hazard models to identify the independent effect of infectious disease geographic density on time to major amputation, controlling for all covariates detailed above. We examined whether the effect of infectious disease physician density would be most pronounced for those presenting with osteomyelitis by constructing a secondary model including interaction terms between infectious disease physician density and ulcer severity. Because a large percentage of patients were expected to die during

2 • OFID • Brennan et al
the study period, and those deaths were likely to be in sicker patients with a higher probability of undergoing major amputation had they survived, we also modeled amputation-free survival. The outcome for this analysis was the number of days from ulcer diagnosis to either major amputation or death. Lastly, we conducted a sensitivity analysis to better control for socioeconomic factors, which may vary by geography and affect the risk of major amputation. We used the area deprivation index, which is a composite measure of 17 US Census indicators of poverty, education, housing, and employment [30]. Values range from 0 to 100, with higher numbers indicative of more deprived areas. The index has been correlated with other health outcomes including all-cause mortality, rehospitalizations, and disease prevalence. We did not include the area deprivation index in our main model because 20.88% of our sample had missing data for this variable, which was not random. A higher proportion of patients living in rural or suburban areas were missing area deprivation index values, which may be attributable to the greater use of post office boxes in these areas. Statistical analyses were performed using Stata version 13.1 (StataCorp LP, College Station, TX).

Ethics
The University of Wisconsin Health Sciences Institutional Review Board approved this study.

RESULTS
Descriptive Summary
A total of 56,440 patients were included in the cohort, with a mean follow-up time of 23.4 months. A total of 6,578 practicing infectious disease physicians were identified in 2006. The median number of infectious disease physicians per 10,000 Medicare beneficiaries in an HRR was 1.09 and ranged from 0 to 7.61. A total of 41,050 (72.73%) patients lived in HRR above the median geographic density of infectious disease physicians, and 15,390 (27.27%) patients resided in HRR below the median. Eight HRRs were low-density outliers, all of which had no infectious disease physicians. Sixty HRRs were high-density outliers, with the highest density of infectious disease physicians located in Washington, DC (Figure 1).

Compared with patients residing in areas of low infectious disease physician density, those living in HRRs with high infectious disease physician density were slightly older, more racially diverse, and had a higher proportion of urban dwellers (Table 1). They had higher rates of myocardial infarcts, ischemic

---

Figure 1. Geographic density of infectious disease physicians in each hospital referral region (HRR) within the United States, 2006. Density was characterized as above or below the median (1.09/10,000 Medicare enrollees in a HRR). Outliers were identified using the blocked adaptive computationally efficient outlier nominators algorithm.
heart disease, and stroke; a higher proportion presented with gangrene. A smaller percentage of patients in high-density HRRs, compared with those in low-density HRRs, saw a primary care physician at least twice in the 2-year baseline period. Of the entire cohort, 4.4% underwent major amputation during the follow-up period and 38.3% died.

### Association Between Geographic Density of Infectious Disease Physicians and Major Amputation

Patients residing in HRRs with high infectious disease physician density experienced fewer major amputations and death compared with those residing in HRRs with low infectious disease physician density (Table 1). Residing in an HRR with a high compared with low density of infectious disease physicians was protective against major amputation in the primary multivariate Cox proportional hazard model (hazard ratio [HR], .83; 95% confidence interval [CI], .75–.91; P < .001) (Table 2). Compared with early-stage ulcers, patients presenting with osteomyelitis or gangrene were significantly more likely to undergo major amputation, respectively (HR = 1.98, 95% CI = 1.69–2.32, P < .001; HR = 9.57, 95% CI = 8.58–10.68, P < .001). However, including interaction terms between these variables indicated that the protective effect of residing in an HRR with high infectious disease physician density

| Characteristic                                      | Percentage of Total Cohort (N = 56,440) | Percentage of the Subset Residing in an HRR With Below/Above Median Infectious Disease Physician Density |
|-----------------------------------------------------|----------------------------------------|--------------------------------------------------------------------------------------------------|
| Age, year, mean (SD)                                | 79.1 (7.8)                             | 78.6 (7.7) 79.3 (7.8)                                                                                       |
| Female                                              | 60.0                                   | 58.4 60.5                                                                                                     |
| Race                                                |                                        |                                                                                                                |
| White                                               | 81.8                                   | 86.8 80.0                                                                                                     |
| Black                                               | 13.0                                   | 9.2 14.4                                                                                                      |
| Other                                               | 5.2                                    | 4.1 5.6                                                                                                       |
| Area of residence                                   |                                        |                                                                                                                |
| South Atlantic                                      | 21.4                                   | 17.6 22.9                                                                                                     |
| Middle Atlantic                                     | 19.0                                   | 7.4 23.3                                                                                                      |
| East North Central                                  | 18.4                                   | 17.9 18.5                                                                                                     |
| West South Central                                  | 10.9                                   | 20.5 7.3                                                                                                      |
| Pacific                                             | 9.5                                    | 9.7 9.4                                                                                                       |
| East South Central                                  | 6.1                                    | 8.5 5.1                                                                                                       |
| West North Central                                  | 5.9                                    | 10.1 4.4                                                                                                      |
| New England                                         | 5.1                                    | 1.9 6.3                                                                                                       |
| Mountain                                            | 3.8                                    | 6.4 2.8                                                                                                       |
| Urbanicity                                          |                                        |                                                                                                                |
| Urban core area                                     | 68.2                                   | 48.3 75.6                                                                                                     |
| Large town area                                     | 11.6                                   | 19.4 8.7                                                                                                      |
| Suburban area                                       | 8.3                                    | 10.5 7.5                                                                                                      |
| Small town/rural                                    | 11.5                                   | 21.6 7.7                                                                                                      |
| Ulcer severity                                      |                                        |                                                                                                                |
| Early                                               | 91.6                                   | 92.0 91.5                                                                                                     |
| Osteomyelitis                                       | 4.6                                    | 4.6 4.7                                                                                                       |
| Gangrene                                            | 3.8                                    | 3.4 3.9                                                                                                       |
| Uncomplicated diabetes                              | 27.0                                   | 28.1 26.6                                                                                                     |
| Prior myocardial infarct                            | 29.3                                   | 28.1 29.8                                                                                                     |
| Ischemic heart disease                              | 86.6                                   | 85.9 86.8                                                                                                     |
| Prior stroke                                        | 38.5                                   | 36.6 40.6                                                                                                     |
| History of eye disease                              | 30.7                                   | 30.9 30.6                                                                                                     |
| At least 2 visits with a primary care provider in the 2-year baseline period | 91.2 | 92.7 90.6 |
| Reason for censoring                                |                                        |                                                                                                                |
| End of study period                                 | 52.2                                   | 50.8 52.7                                                                                                     |
| Death                                               | 38.3                                   | 38.8 38.1                                                                                                     |
| Loss of Medicare coverage                           | 5.1                                    | 5.3 5.1                                                                                                       |
| Major amputation                                    | 4.4                                    | 5.1 4.2                                                                                                       |

Abbreviations: HRR, hospital referral region; SD, standard deviation.
*aData are presented as percentage unless otherwise indicated.*
did not vary based on ulcer severity. Living in an HRR with high infectious disease physician density remained protective against major amputation in the sensitivity analysis, which controlled for sociodemographic factors using the area deprivation index (HR, 0.87; 95% CI, 0.77–0.97; P = .015) (Table 2). In the multivariate analysis modeling amputation-free survival, residing in an HRR with a high density of infectious disease physicians remained statistically significant, but the magnitude of protection was diminished (HR, 0.94; 95% CI, 0.91–0.97; P < .001) (Table 3).

**Association Between Place of Residence and Major Amputation**

Geographic differences in major amputation remained after adjustment. Compared with the South Atlantic region,
residents of the Middle Atlantic, East North Central, Pacific, and Mountain regions had lower hazards of major amputation in the main analysis. Those living in the East and West South Central regions had higher hazards of major amputation (Table 2). Urban dwellers had the lowest hazard ratios for major amputation, compared with other urbanicity categories.

**DISCUSSION**

We found a positive association between access to infectious disease physicians, as measured by their geographic density, and limb preservation for patients with diabetic foot ulcers. This finding suggests that infectious disease physicians may play a beneficial role—direct and/or indirect—in managing diabetic foot ulcers. Multidisciplinary diabetic foot ulcer teams reduce the risk of major amputation, and there is a strong recommendation with moderate-level evidence from IDSA to support their use [13, 31–35]. However, we do not know the optimal constituents of these teams. The IDSA advocates for inclusion or ready access to infectious disease physicians, but there is a low level of evidence to back this recommendation [13, 34, 35]. Our findings support this claim by associating the geographic presence of infectious disease physicians with a reduced risk of
major amputation for patients with diabetic foot ulcers. Our study is also the first to explore the potential role of infectious disease physicians in an ambulatory care sensitive condition. However, the plausibility of a positive impact is substantiated by studies documenting reduced mortality and resource utilization after inpatient infectious disease consultations for a number of different infections, including osteomyelitis [36–38].

We did not find a difference in the impact of infectious disease geographic density on major amputation based on ulcer severity. However, it is possible that none exists when measuring both the direct and indirect effects. Patients with early-stage ulcers may benefit from the direct or indirect input of an infectious disease physician either to avoid the unnecessary use of antibiotics in colonized wounds or to address the skin and soft tissue infections included in this category. The potential for infectious disease physicians to have a direct, positive impact on ulcers complicated by osteomyelitis is likely to be more straightforward, because they have expertise in managing this infection. Benefits in the case of gangrene are also reasonable. Although gangrene is predominantly a surgical issue, the ability to perform a minor amputation with subsequent antibiotic therapy, and thereby avoid a major amputation, often requires input from infectious disease specialists.

After controlling for the density of infectious disease physicians, geographic differences in the risk of major amputation persisted and followed regional trends previously reported [5]. This was expected. Hypotheses for this difference center on variations in medical management and culture [14]. Infectious disease physicians influence both of these facets but are not the sole contributors.

Our study has a number of strengths and is based upon a national sample. Comorbidities, ulcer severity, and major amputation were identified using validated claims algorithms. Infectious disease physician density was calculated using American Medical Association data, rather than relying on Medicare administrative claims specialty codes, which are less sensitive. We found a protective association between infectious disease physician geographic density when modeling both time to major amputation and amputation-free survival. The association was demonstrated in both unadjusted and adjusted analysis, despite increased risk factors for major amputation in the population living in areas with high geographic density of infectious disease physicians.

Our study is limited by the potential for higher geographic densities of infectious disease physicians to be confounded by higher densities of other specialists in the same region. This concern is partially blunted by using HRR as the geographic unit of analysis. All HRRs are defined by tertiary care centers offering specialty care; the range in specialty densities between HRRs should be smaller than if we used hospital service areas, which would not have discriminated between small and large facilities. If we had chosen to assess the impact of direct infectious disease consultation on major amputation, we would have begun to address the concern for confounding by another specialty. However, unless the effects of all other specialists likely to influence the outcome, eg, vascular surgeons, podiatrists, endocrinologists, wound care specialists, were also included in the model, the potential for confounding would still exist. Furthermore, such a model would only estimate the direct effect of infectious disease specialists, introducing a significant limitation given the substantial amount of informal consulting typically provided by infectious disease physicians [19].

Retrospective, claims-based cohorts are also limited in their ability to provide information on other potential confounders. For instance, the absence of laboratory values precluded adjustment for glycemic control. We attempted to control for socioeconomic factors using the area deprivation index in our sensitivity analysis. However, like all metrics, this index is not complete and leaves room for residual confounding.

**CONCLUSIONS**

The association between an increased geographic density of infectious disease physicians and a reduction in major amputation suggests that this specialty may play a role in limb salvage. As well as being clinically plausible, direct assessment of multidisciplinary teams containing infectious disease physicians has shown benefit [34, 35]. These lines of evidence support integration of such specialists into multidisciplinary diabetic foot ulcer care to improve limb salvage. Given the magnitude of diabetic foot ulcers, and decreasing enrollment in infectious disease fellowship training, innovative ways to increase access to infectious disease specialists for this population may be needed in the future [39]. Telehealth, recruiting advanced nurse practitioners or physician assistants, and other outreach initiatives may be helpful.

**Acknowledgments**

We thank Dr. Laura Hogan for editorial assistance.

**Financial support.** This work was supported by the Health Innovation Program, the University of Wisconsin School of Medicine and Public Health from the Wisconsin Partnership Program, and the Community-Academic Partnership core of the University of Wisconsin Institute for Clinical and Translational Research through the National Center for Advancing Translational Sciences (UL1TR000427 and KL2TR000428). Additional support was from Agency for Healthcare Research and Quality (R01 HS018368) and the University of Wisconsin Department of Medicine (through an Individual Research Fellow Supplementation Grant).

**Potential conflicts of interest.** All authors: No reported conflicts.

All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

**References**

1. Lavery LA, Armstrong DG, Murdoch DP, et al. Validation of the Infectious Diseases Society of America’s diabetic foot infection classification system. Clin Infect Dis 2007; 44:562–5.
2. Rogers LC, Andres G, Caporusso J, et al. Toe and flow: essential components and structure of the amputation prevention team. J Am Podiatr Med Assoc 2010; 100:342–8.
3. Mills JL Sr, Conte MS, Armstrong DG, et al. The society for vascular surgery lower extremity threatened limb classification system: risk stratification based on wound, ischemia, and foot infection (WIFIT). J Vasc Surg 2014; 59:220–34.

4. Zhan LX, Branco BC, Armstrong DG, Mills JL Sr. The Society for Vascular Surgery lower extremity threatened limb classification system based on wound, ischemia, and foot infection (WIFIT) correlates with risk of major amputation and time to wound healing. J Vasc Surg 2015; 61:939–44.

5. 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 2003; 24:860–4.

6. Schaper NC. Lessons from Eurodiale. Diabetes Metab Res Rev 2012; 28 (Suppl 1):21–6.

7. Rasmussen BS, Yderstraede KB, Carstensen B, et al. Substantial reduction in the number of amputations among patients with diabetes: a cohort study over 16 years. Diabetologia 2016; 59:121–9.

8. Peters EL, Childs MR, Wunderlich RP, et al. Functional status of persons with diabetes-related lower-extremity amputations. Diabetes Care 2001; 24:1799–804.

9. Brennan MB, Hess TM, Bårle B, et al. Diabetic foot ulcer severity predicts mortality among veterans with type 2 diabetes. J Diabetes Complications 2016; doi: 10.1016/j.jdiacomp.2016.11.020.

10. Hicks CH, Selvarajah S, Mathioudakis N, et al. Trends and determinants of costs associated with the inpatient care of diabetic foot ulcers. J Vasc Surg 2014; 60:1247–54.

11. Davies SM, Geppert J, McClellan M, et al. Refinement of the HCUP quality indicators. Report No.: 01-0035. AHRQ Technical Reviews. Rockville, MD: Agency for Healthcare Research and Quality (US), 2001.

12. Healthy People 2020. Washington, DC: U.S. Department of Health and Human Services, Office of Disease Prevention and Health Promotion. Available at: https://www.healthypeople.gov/2020/topics-objectives/topic/diabetes/objectives. Accessed 19 August 2016.

13. Lipsky BA, Berendt AR, Cornia PB, et al. 2012 Infectious Diseases Society of America clinical practice guideline for the diagnosis and treatment of diabetic foot infections. Clin Infect Dis 2012; 54:e132–73.

14. 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; 34:2363–7.

15. van Battum P, Schaper N, Prompers L, et al. Differences in minor amputation rate ischemia, and foot infection (WIfI) correlates with risk of major amputation and time to wound healing. J Vasc Surg 2015; 61:939–44.

16. Leblebicioglu H, Akbulut A, Ulusoy S, et al. Informal consultations in infectious diseases and clinical microbiology practice. Clin Microbiol Infect 2003; 9:724–6.

17. Petrak RM, Sexton DJ, Butera ML, et al. The value of an infectious diseases specialist: non-patient care activities. Clin Infect Dis 2008; 47:1051–63.

18. Grace C, Alston WK, Ramundo M, et al. The complexity, relative value, and financial worth of curbside consultations in an academic infectious diseases unit. Clin Infect Dis 2010; 51:651–5.

19. Wennberg JE, Cooper MM. The Dartmouth Atlas of Health Care. Chicago, IL: American Hospital Publishing, 1996.

20. The Dartmouth Atlas of Health Care. Available at: http://www.dartmouthatlas.org/tools. Accessed 3 October 2016.

21. The Rural Health Research Center. Available at: www.depts.washington.edu/uwrca/uca-data.php. Accessed 3 October 2016.

22. Economic Research Service. Rural classifications overview. Washington, D.C.: United States Department of Agriculture [March 10, 2014]. Available at: http://www.ers.usda.gov/topics/rural-economy-population/rural-classifications.aspx. Accessed 30 September 2016.

23. Fincke BG, Miller DR, Turpin R. A classification of diabetic foot infections using ICD-9-CM codes: application to a large computerized medical database. BMC Health Serv Res 2010; 10:192.

24. Hebert PL, Geiss LS, Tierney EF, et al. Identifying persons with diabetes using Medicare claims data. Am J Med Qual 1999; 14:220–7.

25. Dubsky M, Jirkovska A, Rem R, et al. Risk factors for recurrence of diabetic foot ulcers: prospective follow-up analysis in the Eurodial subgroup. Int Wound J 2013; 10:555–61.

26. Newton KM, Wagner EH, Ramsey SD, et al. The use of automated data to identify complications and comorbidities of diabetes: a validation study. J Clin Epidemiol 1999; 52:199–207.

27. Billour N, Hadi AS, Velleman PF. BACON: blocked adaptive computationally efficient outlier nominators. Comp Stat Data Anal 2000; 34:279–386.

28. Singh GK. Area deprivation and widening inequalities in US mortality, 1969–1998. Am J Public Health 2003; 93:1137–43.

29. Edmonds ME, Blundell MP, Morris ME, et al. Improved survival of the diabetic foot: the role of a specialized foot clinic. Q J Med 1986; 60:763–71.

30. Wang C, Mai L, Yang C, et al. Reducing major lower extremity amputations after the introduction of a multidisciplinary team in patient with diabetes foot ulcer. BMC Endocr Disord 2016; 16:38.

31. Williams DT, Majed MU, Shingler G, et al. A diabetic foot service established by a department of vascular surgery: an observational study. Ann Vasc Surg 2012; 26:780–6.

32. Larsson J, Apelqvist J, Agardh CD, Stenström A. Decreasing incidence of major amputation in diabetic patients: a consequence of a multidisciplinary foot care team approach? Diabet Med 1995; 12:776–8.

33. Martinez-Gómez DA, Moreno-Carrillo MA, Campillo-Soto A, et al. Reduction in diabetic amputations over 15 years in a defined Spain population. Benefits of a critical pathway approach and multidisciplinary team work. Rev Esp Quimioter 2014; 27:170–9.

34. Lahay T, Shah R, Gittus J, et al. Infectious diseases consultation lowers mortality from Staphylococcus aureus bacteremia. Medicine (Baltimore) 2009; 88:263–7.

35. Schmitt S, McQuillen DP, Nahass R, et al. Infectious diseases specialty intervention is associated with decreased mortality and lower healthcare costs. Clin Infect Dis 2014; 58:22–8.

36. Hamandi B, Husain S, Humar A, Papadimitriou EA. Impact of infectious disease consultation on the clinical and economic outcomes of solid organ transplant recipients admitted for infectious complications. Clin Infect Dis 2014; 59:1074–82.

37. Balken JS. IDSA response to ID match for appointment year 2016. Available at: http://www.idsociety.org/Workforce_Policy/. Accessed 3 October 2016.

**APPENDIX**

**International Statistical Classification of Disease and Related Health Problems, Version 9, Codes (ICD-9 codes) Used to Generate Study Variables**

| Variable | ICD-9 Codes |
|----------|-------------|
| Diabetic foot ulcer | 440.23, 707.1x |
| Early stage | 730.07, 730.17, 730.27, 730.97 |
| Osteomyelitis | 904.0, 440.24 and 785.4 but only if at least one of the following vascular disease codes is also present: 250.7, 440.2, 440.21, 440.22, 440.23 |
| Gangrene | 440.7, 410.x, 427.4, 427.5 |
| Uncomplicated diabetes | 250.00–250.33 |
| Prior myocardial infarction | 411.x, 414.x, 428.x |
| Ischemic heart disease | 411.x, 414.x, 428.x |
| Stroke | 431.x, 432.0, 432.1, 432.9, 434.x, 436.x |
| Eye disease | 361.9, 379.23, procedure code 14.7 |