Laboratory and Pharmaceutical Data Associated With Hospital Readmission in Persons With Diabetic Foot Ulcers

Alyson K. Myers, MD1,2,3,4, Makeda Dawkins, MD5, Inthuja Baskaran, BA4, Stephanie Izard, MPH3,4, Meng Zhang, PhD3,4, Aditya A. Bissoonauth, MPH, MBA, CHES6, Sally Kaplan, RN, CRCC7,8, Amit Rao, MD8, Mohammad Elzanaty, BS4, and Alisha Oropallo, MD, FACS7,8

Abstract
Purpose: Diabetic foot ulcers (DFUs) are a leading cause of lower extremity amputations among persons with diabetes (PWD) and a common cause of hospitalizations. This study identified demographic characteristics, lab values, and comorbidities associated with 30-day and 90-day hospital readmission in persons with DFU.

Methods: A retrospective chart review at our institution examined 397 patients with type 2 diabetes admitted with DFU between January 2014 and December 2018. Variables were analyzed using descriptive statistics, t-tests, and logistic regressions.

Results: None of the studied demographic, laboratory (including Hemoglobin A1c) or comorbid diseases were associated with 30-day readmission in persons with DFU. Risk factors for 90-day readmission included discharge location to home with healthcare services (OR: 2.62, 95% CI: 1.39, 4.95), anticoagulant use (OR: 2.36, 95% CI: 1.27, 4.39), and SQ insulin use (OR: 2.08, 95% CI: 1.20, 3.61).

Conclusions: None of the variables examined were associated with 30-day readmission; however, potential predictors for 90-day readmission included anticoagulation or insulin use and discharge home with healthcare services. Future studies should devise interventions to improve transition of care in patients with DFU to further assess the role of medications and home health care as a potential predictor of 90-day hospital readmission.

Keywords
diabetic foot ulcer, type 2 diabetes, readmissions, wound care, hemoglobin A1c

Highlights

What Do We Already Know About This Topic?
Diabetic foot ulcers lead to high healthcare expenditures as they are a leading cause of lower extremity amputations and hospital admissions.

1Department of Medicine, Division of Endocrinology, North Shore University Hospital, Manhasset, NY, USA
2Donald and Barbara Zucker School of Medicine at Hofstra/Northwell, Hempstead, NY, USA
3Institute for Health System Science, Manhasset, NY, USA
4Feinstein Institute for Medical Research, Manhasset, NY, USA
5Department of Medicine, Westchester Medical Center, Valhalla, NY, USA
6Department of Pediatrics, Cohen Children’s Medical Center, Lake Success, NY, USA
7Department of Surgery, Comprehensive Wound Care Center and Hyperbarics, Lake Success, NY, USA
8Department of Vascular Surgery, Northwell Health, Lake Success, NY, USA

Corresponding Author:
Alyson K. Myers MD, Institute for Health System Science, Northwell Health, 600 Community Drive, Manhasset, NY 11030, USA.
Email: Amyers@northwell.edu

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Introduction

Diabetic foot ulcers (DFUs) are among the leading causes of hospital readmissions, with about 17%–23 of DFU patients readmitted unexpectedly at 30 days.\(^1\) Approximately 30% of patients admitted for DFU are ultimately readmitted within 30 days.\(^2\) Inpatient and follow-up DFU care is estimated to cost about $9–13 billion for Medicare and private insurance.\(^3,4\) The cost of DFU care at one academic institution was $7.9 million over 4 years, with readmissions attributing to about $1.2 million to these expenditures.\(^5\) Analyzing factors contributing to readmission in these persons is not only clinically beneficial but also potentially economically advantageous.

Several studies have investigated the causes of increasing readmission rates amongst DFU patients. Specific DFU-related complications (infection, pain, and hemorrhage) have been identified as the greatest risk factors for readmission.\(^6\) Previous studies have found a positive correlation between HbA1c and readmissions in persons with diabetes, but none have explored this association in those with DFU.\(^7\)

There have been inconsistent findings in regard to HbA1c and wound prognosis.\(^8,9\) Vella et al.\(^8\) found that baseline HbA1c did not predict DFU outcome but those with lower HbA1c had a shorter healing time. Christman et al.\(^10\) noted that larger wounds in patients with HbA1c less than 8% healed better than smaller wounds in patients with an HbA1c over 8%. These results were not replicated by Fesseha et al. in which no significant association was found between baseline HbA1c and wound resolution in patients with DFU regardless of HbA1c.\(^9\) Participants with HbA1c levels at or below 7%, whose values increased throughout the study, experienced paradoxically better long-term healing.\(^9\)

This uncertainty about the relationship between HbA1c and wound healing needs further exploration, as does the relationship between HbA1c and readmission rates for those with DFU. In this retrospective chart review, we examined the relationship between HbA1c and readmissions in persons with type 2 diabetes (T2D) and DFU readmitted between January 2014 and December 2018. Medical, demographic, and pharmaceutical data were also assessed to determine indicators of 30-day and 90-day readmissions. Higher HbA1c (≥7%) was hypothesized to be positively associated with 30-day and 90-day readmission.

Methods

Research Design

An IRB-approved (Approval #19-0486) retrospective chart review was conducted examining patients with T2D and DFU admitted to our hospital between January 2014 and December 2018. Patients were identified using ICD-9 and ICD-10 codes: E11.621, 707.9, E11. 69, E11.628, E11. 610, E11.641, 707.1, E11.622, E11.618, and E08.65. Using the Sunrise® electronic health record, 5991 charts were initially reviewed. Demographic data was extracted, including age, gender, race, ethnicity, as well as data on admission date, length of stay (LOS), comorbidities, body mass index (BMI), HbA1c, c-reactive protein (CRP), ankle–brachial index (ABI), triglycerides, albumin, antibiotics, smoking history, home medications, and insurance. Smoking was categorized as past, current, or never. Insurance was categorized as Medicare, Medicaid, or private. Wound characteristics such as ulcer size, location, and type of amputation were collected from podiatry notes during the associated hospitalization periods.

Participants

Inclusion criteria included age ≥18, T2D, DFU, and admission between January 1st of 2014 and December 31st of 2018. Patients with non-diabetic foot ulcers or those who expired after initial admission were excluded.

Procedure

Among the 5991 charts initially reviewed, 953 charts represented patients with duplicate medical record numbers already included within the study; thus, they were omitted. Between January of 2014 and December of 2018, the initial admission of each patient was recorded. The admission following was recorded as a 30- or 90-day readmission contingent upon the interim period. These time periods were chosen as a) Medicare designates 30 days as the cutoff point for readmissions and b) other studies in the literature have evaluated both 30- and 90-day readmissions.\(^7,11,12\) Among the 5991 charts, another 4388 charts were excluded as their admission diagnoses were unrelated to DFU. The remaining 650 patients were reviewed, where 253 patients were excluded. Two did not have a diagnosis of diabetes mellitus, 100 had non-diabetic foot ulcers, 12 expired during their initial visit, 10 had type 1 diabetes, and 1 had ketosis-prone type 2 diabetes. One hundred twenty one
charts represented outpatient visits, which were excluded. Seven charts were also omitted due to missing outlier data. Ultimately, 397 patients were included in this study (Figure 1) and readmissions were considered for all-causes.

Most subjects included were non-Hispanic white males averaging 65 years old, with a BMI>30 and HbA1c >7% (Table 1). The majority of participants never smoked cigarettes and had private insurance. Many participants also had comorbid hypertension and were using statins, antihypertensives, antibiotics, and subcutaneous insulin.

**Data Collection**

Study data was collected and managed using REDCap electronic data capture tools hosted at our institution. Predictors investigated (Table 2) included age (years); gender (female and male); race (white, black, and other); ethnicity (Hispanic/Latino and not Hispanic/Latino); discharge location (home, home with health care, rehab, and skilled nursing facility); insurance (private, Medicaid, and Medicare); right ABI (none and mild to severe); ABI and ulcer on the same side (yes and no); ulcer size (<1 cm, >1 cm); ulcer location (toe, foot, and leg); and amputation (yes and no). Variables such as smoking status (never, past, and present); BMI (18.5–24.9, 25–29.9, and 30+); HbA1c (< 7%, >7%); HLD (yes and no); obstructive sleep apnea (OSA) (yes and no); HTN (yes and no); chronic kidney disease (CKD) (yes and no); neuropathy (yes and no); retinopathy (yes and no); history of cardiovascular risk factors (MI, CAD, stroke, and PVD) (yes and no); malignancy (yes and no); and PVR (yes and no) were also collected. Steroid use (yes and no); SGLT2 inhibitor use (yes and no); anticoagulant use (yes and no); statin use (yes and no); anti-hypertensive use (yes and no); antibiotic use (yes and no); oral hypoglycemic use (yes and no); and subcutaneous (SQ) insulin use (yes and no) were documented.

**Data Analysis**

Continuous variables were summarized using mean and standard deviation, and categorical variables were summarized using frequency and percent. Continuous variables were then compared across groups using the two-sample t-test or Mann–Whitney U test and categorical variables were compared across groups using the chi-square test or Fisher’s exact test, as appropriate. Descriptive statistics were computed prior to excluding missing data.

Variables with extensive missing data were not considered for inclusion into a multivariable model (CRP, triglyceride, ABI and ulcer same side, ulcer size, amputation, and PVR). Before multivariable analysis, patients with missing or unknown values on all other variables of interest were excluded (n = 68) for a total of 310 patients. For multivariable analysis, a univariable screen was first carried out using logistic regression for all covariates to compute unadjusted odds ratios (ORs) for each of the outcomes. A significance level of .05 was used to determine factors eligible for inclusion in a preliminary multivariable logistic regression model. Variables of
| Demographics/lifestyle | 30-Day Readmission | 90-Day Readmission |
|------------------------|--------------------|--------------------|
|                        | Yes, n (%) | No, n (%) | P-value | Yes, n (%) | No, n (%) | P-value |
| **Age (N = 378), mean (SD)** | 65.85 (12.69) | 66.08 (11.83) | .9082 | 65.67 (12.27) | 66.19 (11.79) | .7067 |
| **Sex (N = 378)** | | | | | | |
| Female | 11 (10.19) | 97 (89.81) | .8740 | 26 (24.07) | 82 (75.93) | .4622 |
| Male | 29 (10.74) | 241 (89.26) | | 75 (27.78) | 195 (72.22) | |
| **Race (N = 372)** | | | | | | |
| White | 22 (10.33) | 191 (89.67) | .1842 | 57 (26.76) | 156 (73.24) | .0468 |
| Black | 9 (10.84) | 74 (89.16) | | 22 (26.51) | 61 (73.49) | |
| Asian | 6 (22.22) | 21 (77.78) | | 13 (48.15) | 14 (51.85) | |
| Other/multiracial | 3 (6.12) | 46 (93.88) | | 9 (18.37) | 40 (81.63) | |
| **Ethnicity (N = 371)** | | | | | | |
| Hispanic/Latino | 1 (4.76) | 20 (95.24) | .7136 | 6 (28.57) | 15 (71.43) | .8864 |
| Not Hispanic/Latino | 39 (11.14) | 311 (88.86) | | 95 (27.14) | 255 (72.86) | |
| **Smoking (N = 363)** | | | | | | |
| Never | 18 (8.26) | 200 (91.74) | .2227 | 54 (24.77) | 164 (75.23) | .5236 |
| Past | 15 (14.42) | 89 (85.58) | | 32 (30.77) | 72 (69.23) | |
| Present | 5 (12.20) | 36 (87.80) | | 11 (26.83) | 30 (73.17) | |
| **BMI (N = 368)** | | | | | | |
| 18.5–24.9 | 6 (8.57) | 64 (91.43) | .3528 | 15 (21.43) | 55 (78.57) | .5384 |
| 25–29.9 | 16 (14.04) | 98 (85.96) | | 31 (27.19) | 83 (72.81) | |
| 30+ | 17 (9.24) | 167 (90.76) | | 52 (28.26) | 132 (71.74) | |
| **Admission related** | | | | | | |
| Length of stay (days) (N = 378), mean (SD) | 11.60 (17.07) | 11.89 (19.86) | .4379 | 11.47 (12.72) | 12.00 (21.54) | .5301 |
| **Discharge location (N = 366)** | | | | | | |
| Home | 9 (7.89) | 105 (92.11) | .6742 | 21 (18.42) | 93 (81.58) | .0288 |
| Home w/health care | 20 (12.50) | 140 (87.50) | | 54 (33.75) | 106 (66.25) | |
| Rehab | 7 (10.45) | 60 (89.55) | | 15 (22.39) | 52 (77.61) | |
| Hospice/SNF | 3 (12.00) | 22 (88.00) | | 8 (32.00) | 17 (68.00) | |
| **Insurance (N = 372)** | | | | | | |
| Medicare | 12 (11.21) | 95 (88.79) | .9258 | 34 (31.78) | 73 (68.22) | .2025 |
| Private | 23 (10.90) | 188 (89.10) | | 57 (27.01) | 154 (72.99) | |
| Medicaid | 5 (9.26) | 49 (90.74) | | 10 (18.52) | 44 (81.48) | |
| **Clinical** | | | | | | |
| Right ABI (N = 128) | | | | | | |
| Normal | 9 (9.78) | 83 (90.22) | 1.0000 | 6 (16.67) | 30 (83.33) | .2580 |
| Mild–severe | 3 (8.33) | 33 (91.67) | | 24 (26.09) | 68 (73.91) | |

(continued)
|                                      | 30-Day Readmission | 90-Day Readmission |
|--------------------------------------|--------------------|--------------------|
|                                      | Yes, n (%)         | No, n (%)          | P-value | Yes, n (%)         | No, n (%)          | P-value |
| Left ABI (N = 119)                   |                    |                    | .7526   |                    |                    | .3868   |
| Normal                               | 9 (10.47)          | 77 (89.53)         |         | 25 (29.07)         | 61 (70.93)         |         |
| Mild–severe                          | 4 (12.12)          | 29 (87.88)         |         | 7 (21.21)          | 26 (78.79)         |         |
| ABI and ulcer same side (N = 135)   |                    |                    | .5335   |                    |                    | .1516   |
| Yes                                  | 5 (12.20)          | 36 (87.80)         |         | 7 (17.07)          | 34 (82.93)         |         |
| No                                   | 8 (8.51)           | 86 (91.49)         |         | 27 (28.72)         | 67 (71.28)         |         |
| Ulcer size (N = 108)                 |                    |                    | .6875   |                    |                    | .0476   |
| ≤1 cm                                | 1 (5.88)           | 16 (94.12)         |         | 2 (11.76)          | 15 (88.24)         |         |
| >1 cm                                | 12 (13.19)         | 79 (86.81)         |         | 33 (36.26)         | 58 (63.74)         |         |
| Ulcer location (N = 371)             |                    |                    | .4716   |                    |                    | .9471   |
| Toe                                  | 14 (10.94)         | 114 (89.06)        |         | 33 (25.78)         | 95 (74.22)         |         |
| Foot                                 | 16 (8.60)          | 170 (91.40)        |         | 51 (27.42)         | 135 (72.58)        |         |
| Leg                                  | 8 (14.04)          | 49 (85.96)         |         | 15 (26.32)         | 42 (73.68)         |         |
| Amputation (N = 148)                 |                    |                    | .6826   |                    |                    | 1.0000  |
| Yes                                  | 14 (10.53)         | 119 (89.47)        |         | 39 (29.32)         | 94 (70.68)         |         |
| No                                   | 2 (12.50)          | 14 (87.50)         |         | 4 (25.00)          | 12 (75.00)         |         |
| HLD (N = 378)                        |                    |                    | .3511   |                    |                    | .1655   |
| Yes                                  | 23 (12.04)         | 168 (87.96)        |         | 57 (29.84)         | 134 (70.16)        |         |
| No                                   | 17 (9.09)          | 170 (90.91)        |         | 44 (23.53)         | 143 (76.47)        |         |
| OSA (N = 378)                        |                    |                    | .2293   |                    |                    | .1994   |
| Yes                                  | 5 (16.67)          | 25 (83.33)         |         | 11 (36.67)         | 19 (63.33)         |         |
| No                                   | 35 (10.06)         | 313 (89.94)        |         | 90 (25.86)         | 258 (74.14)        |         |
| HTN (N = 377)                        |                    |                    | .0802   |                    |                    | .1847   |
| Yes                                  | 35 (12.15)         | 253 (87.85)        |         | 82 (28.47)         | 206 (71.53)        |         |
| No                                   | 5 (5.62)           | 84 (94.38)         |         | 19 (21.35)         | 70 (78.65)         |         |
| CKD (N = 377)                        |                    |                    | .8688   |                    |                    | .0085   |
| Yes                                  | 9 (11.11)          | 72 (88.89)         |         | 31 (38.27)         | 50 (61.73)         |         |
| No                                   | 31 (10.47)         | 265 (89.53)        |         | 70 (23.65)         | 226 (76.35)        |         |
| Neuropathy (N = 377)                 |                    |                    | .6252   |                    |                    | .5241   |
| Yes                                  | 8 (9.20)           | 79 (90.80)         |         | 21 (24.14)         | 66 (75.86)         |         |
| No                                   | 32 (11.03)         | 258 (88.97)        |         | 80 (27.59)         | 210 (72.41)        |         |
| Retinopathy (N = 377)                |                    |                    | .2347   |                    |                    | .3861   |
| Yes                                  | 3 (18.75)          | 13 (81.25)         |         | 6 (37.50)          | 10 (62.50)         |         |
| No                                   | 37 (10.25)         | 324 (89.75)        |         | 95 (26.32)         | 266 (73.68)        |         |
| MI/CAD/stroke/PVD (N = 377)          |                    |                    | .2447   |                    |                    | .0127   |
| Yes                                  | 23 (12.50)         | 161 (87.50)        |         | 60 (32.61)         | 124 (67.39)        |         |
| No                                   | 17 (8.81)          | 176 (91.19)        |         | 41 (21.24)         | 152 (78.76)        |         |

(continued)
|                                | 30-Day Readmission | 90-Day Readmission |
|--------------------------------|---------------------|---------------------|
|                                | Yes, n (%)          | No, n (%)           | P-value |
|                                |                     |                     |         |
| Malignancy (N = 377)           |                     |                     |         |
| Yes                            | 6 (15.00)           | 34 (85.00)          | .4110   |
| No                             | 34 (10.09)          | 303 (89.91)         |         |
| PVR (N=157)                    |                     |                     | .9841   |
| Normal                         | 7 (10.77)           | 58 (89.23)          |         |
| Abnormal                       | 10 (10.87)          | 82 (89.13)          |         |
| Labs                            |                     |                     | .3929   |
| A1c                            |                     |                     | .3236   |
| ≤7                             | 10 (8.77)           | 104 (91.23)         |         |
| >7                             | 30 (11.76)          | 225 (88.24)         |         |
| CRP (N = 210), mean (SD)       |                     |                     | .7434   |
| Normal                         | 6.75 (6.27)         | 8.25 (13.16)        |         |
| Abnormal                       | 125.90 (94.85)      | 131.94 (90.73)      |         |
| Albumin (N = 368), mean (SD)   |                     |                     | .4941   |
| Steroid                        |                     |                     | .3700   |
| Yes                            | 5 (15.15)           | 28 (84.85)          |         |
| No                             | 34 (10.06)          | 304 (89.94)         |         |
| SGLT2 inhibitor (N = 371)      |                     |                     | 1.0000  |
| Yes                            | 1 (6.25)            | 15 (93.75)          |         |
| No                             | 38 (10.70)          | 317 (89.30)         |         |
| Anticoagulant (N = 371)        |                     |                     | .0920   |
| Yes                            | 11 (16.18)          | 57 (83.82)          |         |
| No                             | 28 (9.24)           | 275 (90.76)         |         |
| Statin use (N = 371)           |                     |                     | .2608   |
| Yes                            | 29 (11.79)          | 217 (88.21)         |         |
| No                             | 10 (8.00)           | 115 (92.00)         |         |
| Antihypertensive (N = 371)     |                     |                     | .7094   |
| Yes                            | 31 (10.23)          | 272 (89.77)         |         |
| No                             | 8 (11.76)           | 60 (88.24)          |         |
| Antibiotic (N = 375)           |                     |                     | 1.0000  |
| Yes                            | 37 (10.72)          | 308 (89.28)         |         |
| No                             | 3 (10.00)           | 27 (90.00)          |         |
| Oral hypoglycemic (N = 372)    |                     |                     | .5237   |
| Yes                            | 15 (9.55)           | 142 (90.45)         |         |
| No                             | 25 (11.63)          | 190 (88.37)         |         |
| SQ insulin (N = 371)           |                     |                     | .3222   |
| Yes                            | 26 (11.82)          | 194 (88.18)         |         |
| No                             | 13 (8.61)           | 138 (91.39)         |         |
Table 2. Association Between Predictors and 90-Day Readmission, Final Multivariable Model.

| Discharge location                              | OR (95% CI) |
|------------------------------------------------|-------------|
| Home with healthcare vs home                   | 2.62 (1.39, 4.95) |
| Hospice/Skilled nursing facility vs home       | 1.65 (0.54, 5.07) |
| Rehabilitation facility vs home                | 1.08 (0.47, 2.47) |
| Anticoagulation use                            |             |
| Yes vs no                                      | 2.36 (1.27, 4.39) |
| SQ insulin use                                 |             |
| Yes vs no                                      | 2.08 (1.20, 3.61) |

Amongst persons with diabetes, those with DFU have a greater rate of mortality compared to those without DFU due to their burden of CKD as well as cardiovascular disease, in addition to their standing risk of hospital admissions secondary to CKD and cardiovascular comorbidities independently.

Medications such as anticoagulants and insulin formulations were commonly used among the participants and were all positively associated with readmission. Interestingly, previous research contradicts the results of the current study. Anticoagulant usage has been found to reduce ulcer size and in some cases heal wounds. In this study, anticoagulation usage paradoxically increased the likelihood of readmission.2.36 (1.27, 4.39). This could be due to delayed healing secondary to prolonged bleeding, which is noted to independently extend hospitalizations. Holscher et al. noted that the primary reason for unplanned 30-day readmission was deterioration and treatment of the wound (41%). These studies suggest that increased wound healing time, potentially caused by anticoagulants, can increase rates of readmission. Our results correlate with this association but do not suggest causation. We found an association between MI/CAD/stroke/PVD and 90-day readmission on bivariate analysis (Table 1). However, after exclusions were made for the multivariable model, this relationship was no longer significant. Margolis et al. noted the more advanced stage of CKD, the greater the association with both DFU and amputation regardless of the presence of PAD.13

Discussion

Glycemic control as measured by HbA1c greater or less than 7% was not associated with 30- or 90-day readmissions, despite the fact that glycemic control is associated with wound healing. Christman et al. observed a .028 cm² decrease in healing rate per day for each 1.0% increase in HbA1c.16 Anticoagulation use, use of subcutaneous insulin, and discharge to home with healthcare services were statistically significant in their association with higher rates of 90-day readmission.

DFU and amputations have traditionally been associated with comorbid CKD, as both are manifestations of the microvascular sequelae of diabetes mellitus. In this study, we found an association between CKD and 90-day readmission on bivariate analysis (Table 1). However, after exclusions were made for the multivariable model, this relationship was no longer significant. Margolis et al. noted the more advanced stage of CKD, the greater the association with both DFU and amputation regardless of the presence of PAD.13 Amongst persons with diabetes, those with DFU have a greater rate of mortality compared to those without DFU due to their burden of CKD as well as cardiovascular disease, in addition to their standing risk of hospital admissions secondary to CKD and cardiovascular comorbidities independently.

In summary, glycemic control, anticoagulant use, ulcer size, CKD, MI/CAD/stroke/PVD, anticoagulant use, and SQ insulin use were positively associated with readmission. Interestingly, glycemic control as measured by HbA1c greater or less than 7% was not associated with 30- or 90-day readmissions.
of the injection in their abdomen. Such findings would suggest insulin usage would prevent readmission for DFU; however, our results demonstrated that SQ insulin users 2.08 (1.2, 3.61) were at a higher risk for 90-day readmission. Tight blood glucose control has been consistently documented to aid in rapid healing of diabetic foot ulcers and decrease the risk of amputation. As a result, the Society for Vascular Surgery, the American Podiatric Medical Association, and the Society for Vascular Medicine recommend that persons with DFU have an HbA1c of 7% or less. Our retrospective study utilized medication reconciliation data to determine current pharmaceutical prescriptions but did not account for medical adherence. As such, participants may have been prescribed insulin but may have been following an inconsistent regimen, leading to the inverse association observed. In addition, these risk factors may be seen due to the fact that these patients are sicker or have a worse disease course.

Our results demonstrated patients discharged to home with healthcare services were more likely to be readmitted. This has been previously reported in diseases such as congestive heart failure, but this is not well-studied in those with diabetes. Some of the reasons for increased readmissions for patients who receive home care includes higher frequency of provider visits and poor communication between the home care nurse and the provider. Jafary et al. had one of the few studies on home wound care. They noted that by discharging patients with DFU home and setting them up with home care nursing in a Hospital-In-A-Home program, both saved money and led to faster wound healing when compared to those who were hospitalized. Their study did not assess the rate of readmissions.

**Limitations**

This study had several limitations due to its retrospective nature. Multiple data points such as ulcer size, ulcer location, and ABI/PVR results were missing and thus could not be considered in the multivariable model. Variations in ulcer size may also be present as the manual measurement may have been somewhat subjective and rounded according to personal discernment. Interventions performed for patients with peripheral artery disease were not detailed. Additionally, medication recordings and coding errors were noted. Anticoagulation brand and/or generic names were not specified, which also would have helped to better delineate outcomes. This study may have also been subject to additional confounding variables not assessed, potentially influencing the results of the study. As a study conducted at a single center with predominantly white male obese participants, these results may not be generalizable. An increased presence of ethnic minorities could have altered comorbidity and insurance data, in correlation with racial disparities in BMI, CAD, HTN, etc. and insurance coverage, further increasing readmissions. Moreover, the single-center design restricts the ability to determine causation while only providing association. Additionally, this work did not account for readmission at different institutions within and independent of our institution. A multi-center randomized prospective study using wound grading or classification would be optimal to greater identify demographic factors, comorbidities, and laboratory data associated with readmission in DFU patients and yield more generalizable results. It would also be of benefit to further stratify HbA1c values to see if there was a greater association between higher HbA1c (ie, over 10%) and readmission.

**Conclusions**

Patients with DFU discharged home with health care were more likely to be readmitted after 90 days. Likewise, those using anticoagulation or SQ insulin were at higher risk for 90-day readmission. Interestingly, these effects were not seen in the 30-day period and no association was seen with hemoglobin A1c at either time period.

Understanding the underlying cause for readmissions in persons with DFU still needs to be further explored. Conducting focus groups or semi-structured interviews to obtain qualitative data in this area would be of benefit. The combination of both qualitative and prospective quantitative data can be used to design an intervention aimed at targeting identified obstacles to health maintenance and reducing the need for readmissions. It would also be of use to assess the home care nurses evaluations of such patients as their use was associated with higher readmission rates in patients with DFU.

As hospitals continue to develop programs to decrease readmissions, programs focused on those with diabetes need to be devised as persons with diabetes have greater rates of readmissions than those without; these readmissions can be for diabetic complications such as DFU or other comorbid conditions. Identifying those higher risk patients and determining the factors which contribute to their readmissions will improve health outcomes and decrease healthcare expenditures.

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Alyson K. Myers  
ORCID iD  
https://orcid.org/0000-0002-9973-6653

References
1. Holscher CM, Hicks CW, Canner JK, et al. Unplanned 30-day readmission in patients with diabetic foot wounds treated in a multidisciplinary setting. J Vasc Surg. 2018;67(3):876-886. doi:10.1016/j.jvs.2017.07.131.
2. Remington AC, Hernandez-Boussard T, Warstadt NM, et al. Analyzing treatment aggressiveness and identifying high-risk patients in diabetic foot ulcer return to care. Wound Repair Regen. 2016;24(4):731-736. DOI: 10.1111/wrr.12439.
3. Raghav A, Khan ZA, Labala RK, Ahmad J, Noor S, Mishra BK. Financial burden of diabetic foot ulcers to world: a progressive topic to discuss always. Ther Adv Endocrinol Metab. 2018;9(1):29-31. doi:10.1177/2042018817744513.
4. Rice JB, Desai U, Cummings AKG, Birnbaum HG, Skornicki M, Parsons NB. Burden of diabetic foot ulcers for medicare and private insurers. Diabetes Care. 2014;37(3):651-658. doi:10.2337/dc13-2176.
5. Hicks CW, Canner JK, Karagolzu H, et al. Contribution of 30-day readmissions to the increasing costs of care for the diabetic foot. J Vasc Surg. 2019;70(4):1263-1270. doi:10.1016/j.jvs.2018.12.028.
6. Yazdanpanah L, Nasiri M, Adarvishi S. Literature review on the management of diabetic foot ulcer. World J Diabetes. 2015;6(1):37-53. doi:10.4239/wjd.v6.i1.37.
7. Dungan KM. The effect of diabetes on hospital readmissions. J diabetes science technol. 2012;6(5):1045-1052.
8. Vella L, Gatt A, Formosa C. Does baseline hemoglobin A1c level predict diabetic foot ulcer outcome or wound healing time? J Am Podiatr Med Assoc. 2017;107(4):272-279. doi:10.7547/15-176.
9. Fessaha BK, Abularrage CJ, Hines KF, et al. Association of hemoglobin A1c wound healing in diabetic foot ulcers. Diabetes Care. 2018;41(7):1478-1485. doi:10.2337/dc17-1683.
10. Christman AL, Selvin E, Margolis DJ, Lazarus GS, Garza LA. Hemoglobin A1c predicts healing rate in diabetic wounds. J Invest Dermatol. 2011;131(10):2121-2127. doi:10.1038/jid.2011.176.
11. Hospital Readmissions Reduction Program (HRRP) | CMS. https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/Readmissions-Reduction-Program. Accessed December 11, 2020
12. Lee PH, Franks AS, Barlow PB, Farland MZ. Hospital readmission and emergency department use based on prescribing patterns in patients with severely uncontrolled type 2 diabetes mellitus. Diabetes Technol Therapeut. 2014;16(3):150-155. doi:10.1089/dia.2013.0168.
13. Margolis DJ, Hofstad O, Feldman HI. Association between renal failure and foot ulcer or lower-extremity amputation in patients with diabetes. Diabetes Care. 2008;31(7):1331-1336. doi:10.2337/dc07-2244.
14. Young MJ, McCordle JE, Randall LE, Barclay JI. Improved survival of diabetic foot ulcer patients 1995-2008: possible impact of aggressive cardiovascular risk management. Diabetes Care. 2008;31(11):2143-2147. doi:10.2337/dc08-1242.
15. Galvan L. Effects of heparin on wound healing*1. Journal of WOCN. 1996;23(4):224-226. doi:10.1016/S1071-5754(96)90095-9.
16. Drugs that delay wound healing. Prescrir Int. 2013;22(137):94-98.
17. Thomas Hess C. Checklist for factors affecting wound healing. Adv Skin Wound Care. 2011;24(4):192. doi:10.1097/01.ASW.0000396300.04173
18. Emanuelli T, Burgeiro A, Carvalho E. Effects of insulin on the skin: possible healing benefits for diabetic foot ulcers. Arch Dermatol Res. 2016;308(10):677-694. doi:10.1007/s00403-016-1866-z.
19. Zhang Z, Lv L. Effect of local insulin injection on wound vascularization in patients with diabetic foot ulcer. Exp Ther Med. 2016;11(2):397-402. doi:10.3892/etm.2015.2917.
20. Brownrigg JRW, Davey J, Holt PJ, et al. The association of ulceration of the foot with cardiovascular and all-cause mortality in patients with diabetes: a meta-analysis. Diabetologia. 2012;55(11):2906-2912. doi:10.1007/s00125-012-2673-3.
21. Hasan R, Firwana B, Elraiyah T, et al. A systematic review and meta-analysis of glycemic control for the prevention of diabetic foot syndrome. J Vasc Surg. 2016;63(2 suppl):22S-28S. e2. doi:10.1016/j.jvs.2015.10.005.
22. Hingorani A, LaMuraglia GM, Henke P, et al. The management of diabetic foot: a clinical practice guideline by the society for vascular surgery in collaboration with the American podiatric medical association and the society for vascular medicine. J Vasc Surg. 2016;63(2 suppl):3S-21S. doi:10.1016/j.jvs.2015.10.003.
23. Ma C, Shang J, Miner S, Lennox L, Squires A. The prevalence, reasons, and risk factors for hospital readmissions among home health care patients: a systematic review. Home Health Care Manag Pract. 2018;30(2):83-92. doi:10.1177/1084822317741622.
24. Jafary M, Amini M, Sanjari M, et al. Comparison home care service versus hospital-based care in patients with diabetic foot ulcer: an economic evaluation study. J Diabetes Metab Disord. 2020;19(1):445-452. doi:10.1007/s40200-020-00527-y.
25. Rubin DJ, Golden SH, McDonnell ME, Zhao H. Predicting readmission risk of patients with diabetes hospitalized for cardiovascular disease: a retrospective cohort study. J Diabetes Complicat. 2017;31(8):1332-1339. doi:10.1016/j.jdiacomp.2017.04.021.