Evidence-Based Chronic Ulcer Care And Lower Limb Outcomes Among Pacific Northwest Veterans

By: Mahsa Karavan MPH, MD, John Olerud MD, **Erin Bouldin MPH, PhD**, Leslie Taylor PhD, and Gayle E. Reiber MPH, PhD

Abstract

Evidence-based ulcer care guidelines detail optimal components of care for treatment of ulcers of different etiologies. We investigated the impact of providing specific evidence-based ulcer treatment components on healing outcomes for lower limb ulcers (LLU) among veterans in the Pacific Northwest. Components of evidence-based ulcer care for venous, arterial, diabetic foot ulcers/neuropathic ulcers were abstracted from medical records. The outcome was ulcer healing. Our analysis assessed the relationship between evidence-based ulcer care by etiology, components of care provided, and healing, while accounting for veteran characteristics. A minority of veterans in all three ulcer-etiology groups received the recommended components of evidence-based care in at least 80% of visits. The likelihood of healing improved when assessment for edema and infection were performed on at least 80% of visits (hazard ratio [HR] = 3.20, p = 0.009 and HR = 3.54, p = 0.006, respectively) in patients with venous ulcers. There was no significant association between frequency of care components provided and healing among patients with arterial ulcers. Among patients with diabetic/neuropathic ulcers, the chance of healing increased 2.5-fold when debridement was performed at 80% of visits (p = 0.03), and doubled when ischemia was assessed at the first visit (p = 0.045). Veterans in the Pacific Northwest did not uniformly receive evidence-based ulcer care. Not all evidence-based ulcer care components were significantly associated with healing. At a minimum, clinicians need to address components of ulcer care associated with improved ulcer healing.

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ABSTRACT

Evidence-based ulcer care guidelines detail optimal components of care for treatment of ulcers of different etiologies. We investigated the impact of providing specific evidence-based ulcer treatment components on healing outcomes for lower limb ulcers (LLU) among veterans in the Pacific Northwest. Components of evidence-based ulcer care for venous, arterial, diabetic foot ulcers/neuropathic ulcers were abstracted from medical records. The outcome was ulcer healing. Our analysis assessed the relationship between evidence-based ulcer care by etiology, components of care provided, and healing, while accounting for veteran characteristics. A minority of veterans in all three ulcer-etiology groups received the recommended components of evidence-based care in at least 80% of visits. The likelihood of healing improved when assessment for edema and infection were performed on at least 80% of visits (hazard ratio [HR] = 3.20, $p = 0.009$ and HR = 3.54, $p = 0.006$, respectively) in patients with venous ulcers. There was no significant association between frequency of care components provided and healing among patients with arterial ulcers. Among patients with diabetic/neuropathic ulcers, the chance of healing increased 2.5-fold when debridement was performed at 80% of visits ($p = 0.03$), and doubled when ischemia was assessed at the first visit ($p = 0.045$). Veterans in the Pacific Northwest did not uniformly receive evidence-based ulcer care. Not all evidence-based ulcer care components were significantly associated with healing. At a minimum, clinicians need to address components of ulcer care associated with improved ulcer healing.

Chronic lower limb ulcers (LLU) occur most commonly as the result of complications of venous hypertension, arterial insufficiency, and diabetes. Evidence-based (EB) guidelines for etiology-specific ulcer care exist.[1-5] Yet in both specialty and general settings, the delivery of evidence-based ulcer care is not uniform. Reasons include the broad clinical spectrum of chronic ulcers, variation in diagnosis and treatment, differences in rural-urban access, poor care coordination between generalist and specialist providers caring for the same patient and contributions from other medical comorbidities.

Components of EB ulcer care have been associated with improved wound healing for venous, arterial, and DFU/neuropathic ulcers (Table 1). Evidence-based ulcer care is associated with improvements in chronic venous ulcer outcomes, which account for over 70% of all LLUs.27 A study by Olson and associates assessed the impact of EB ulcer care on venous ulcer healing and reported that the likelihood of ulcer healing among veterans increased when compression therapy, sharp debridement, and moist wound healing were all provided in at least 80% of visits (RR = 2.52; 95% confidence interval [CI]: 1.53–4.16).6 Compression therapy and moist wound healing both independently increased the likelihood of healing when performed at ≥80% of visits, however debridement alone was not significantly associated with venous ulcer healing.6

Table 1. Chronic ulcer definition and evidence-based ulcer care components

Ulcer etiology and evidence-based references	Evidence-based ulcer care components	Ulcer etiology definitions
Venous		
1– 3, 6-13	1- Compression therapy: edema control could be achieved through the use of compression stockings or dressings or by elevating the lower extremities	Ulcers due to venous incompetence most commonly occur above the medial or lateral malleoli11
2– 3, 8, 12-15	2- Moist wound healing: application of dressing that maintains moist wound environment. All major moist dressings were considered, for example Duoderm, Hydrosorb, Aquaphore, hydrocolloid and Alginate dressing, Tegaderm, Allevyn, Vaseline gauze, etc.	
3– 3, 16, 17	3- Sharp debridement: remove all necrotic or devitalized tissue by surgical and mechanical means	
Arterial		
1 and 2– 1, 18-21	1- Assess ischemia (palpable pedal pulses, ABI > 0.8, normal Doppler waveform, normal color duplex ultrasound, toe-brachial index > 0.7) 2- Evaluation for revascularization: in this study a vascular surgery encounter within 30 days of ulcer onset was considered a component of ulcer care	Caused by poor perfusion to the lower limbs and often affects the toes or shin or occurs over pressure points.11 Findings include absent pedal pulses, ABI < 0.9 and/or MRI/ultrasound evidence of arterial blockage
DFU/Neuropathic		
1– 2, 18-21	1- Assess ischemia (palpable pedal pulses, ABI > 0.8, normal Doppler	Usually occurs on plantar aspect of feet or over pressure points in

Ulcer etiology and evidence-based references	Evidence-based ulcer care components	Ulcer etiology definitions
	waveform, normal color duplex ultrasound, toe-brachial index > 0.7)	patients with diabetes and neurologic disorders[11]
2– [2, 4, 22]	2- Offloading: crutches, walkers, wheelchairs, custom shoes, depth shoes, shoe modifications, custom inserts, custom relief orthotic walkers (CROW), diabetic boots, forefoot and heel relief shoes, and total contact casts	
3– [2, 14]	3- Moist wound healing: see above for venous ulcers	
4– [2, 16, 23, 24]	4- Sharp debridement: see above for venous ulcers	
All chronic ulcers [1-3, 25, 26]	Infection assessment: ulcer examination for signs of invasive bacterial infection of soft tissue or bone	

Arterial insufficiency, the second most common cause of LLUs, accounts for 10–30% of all chronic LLUs.[27] Diabetic ulcers comprising 15–25% of LLUs,[27] have the worst prognosis and the highest amputation rate.[5, 28] As the prevalence of diabetes is higher among veterans (24%) than the general population (8%), they experience higher rates of diabetes-related ulcers and amputations.[29]

In spite of existing ulcer guidelines, there is still a significant practice gap in the evidence-based diagnosis and treatment of these ulcers.[30] The purpose of this study is to investigate the frequency that components of EB ulcer care are performed in rural and urban VA settings within the Northwest Health Network (VISN 20) of the U.S. Department of Veterans Affairs (VA) Health System, and their impact on LLU outcomes among veterans. We hypothesized that veterans receiving EB ulcer care would experience improved ulcer outcomes.

METHODS

Subject selection

This study, a retrospective medical records review, was conducted in VA's VISN 20, which included 8 medical centers and 23 community based outpatient clinics (CBOCs). This project was approved by VA Puget Sound Health Care System Institutional Review Board. A set of high-probability ICD-9 codes ($n = 46$), based on previous studies, was used to identify potential subjects with at least one incident LLU between October 1, 2006 and September 30, 2007.[31] The parent study, examining differences between rural and urban veterans, screened a randomized list

of potential patients until 160 rural and 160 urban veterans who met inclusion criteria were identified. All 320 veterans had a chronic LLU, defined as an open wound that did not heal within 30 days of the first VA treatment visit. Ulcers were associated with at least two VA encounters, at least one of which had to be outpatient. Veterans who died within 30 days of ulcer onset were excluded.

Following identification of the 320 patients in the parent study, ulcer etiology was determined by reviewing all progress notes and diagnostic tests relating to ulcer care. Ulcers with venous, arterial, and DFU/neuropathic etiology were included; all other ulcers (pressure ulcers [*n* = 31], infection only [*n* = 32], dermatological conditions, trauma and other [*n* = 33]) were excluded from this study. Figure 1 illustrates the algorithm used to categorize arterial, venous, and DFU/neuropathic ulcers. The first branch point was based on peripheral arterial status. Both ankle brachial index (ABI) < 0.8 and arterial imaging studies were used to assess arterial status. If severe arterial disease was not identified, ulcers were further categorized as venous or DFU/neuropathic. Although most veterans in this study had multiple comorbidities, ulcer etiology was determined based on clinical testing and/or specialist assessment. For example, a veteran with severe PAD meeting the above peripheral arterial disease criteria was classified as having arterial ulcer etiology despite a history of venous disease. Someone with diabetes who experienced a new venous ulcer would be classified with venous ulcer etiology. Ulcers were classified as having mixed etiology if, based on specialist assessment, more than one etiology contributed to the nonhealing ulcer. Foot ulcers in veterans with nondiabetic neuropathy were combined with diabetic foot ulcers for analysis as management of purely neuropathic ulcers are not separated from DFU in the literature and because there were a small number of this these ulcers.

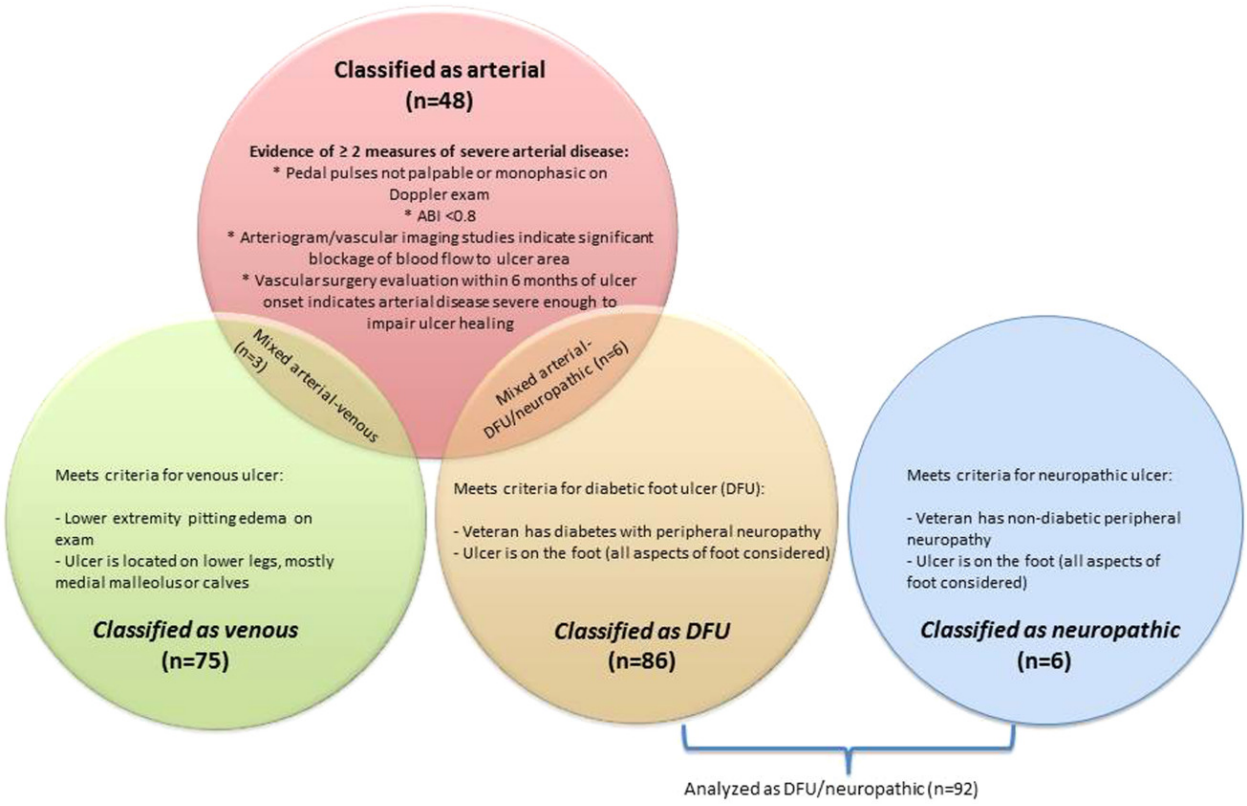

Figure 1

Retrospective ulcer etiology determination using provider progress notes, $n = 224$. If ABI >1.0 or if arteries were incompressible then ABI was not used to classify etiology; in these cases, more advanced imaging and/or vascular surgery consult notes including clinical judgment were used to classify ulcers.

Data collection

We abstracted medical records from the VA's Computerized Patient Record System (CPRS) to collect demographic, health-history, and ulcer care-related variables from October 1, 2006 to September 30, 2007. A chronic ulcer was defined as a wound that did not heal completely after receiving medical treatment for 30 days, base on the Centers for Medicare and Medicaid Services definition.[32] Ulcer related progress notes were reviewed for documentation of ulcer care treatment components and ulcer outcomes. The following elements were recorded for every visit: provider assessment for ulcer infection, sharp debridement, offloading implementation, moist wound healing environment, edema assessment, edema control, LL ischemia assessment, presence/absence of LL ischemia, antibiotic prescription for systemic and/or wound infection, imaging and surgical procedures, global assessment, and follow-up planning. The primary outcome, healing, was defined as the complete re-epithelialization of the ulcer with documented maintenance of skin integrity for at least 30 days, based on wound care provider chart notes.

Health history was recorded at baseline (first ulcer treatment visit) based on medical record and provider diagnosis. All conditions were classified as present or absent except diabetes which was a three-level variable based on ADA criteria: no diabetes, diabetes and HbA1c ≤7, and diabetes and HbA1C levels >7.[33] Veterans were classified as "ever" smokers if a progress note said they currently smoked or had smoked in the past.

Rural residence was defined using the VA's classification system, based on United States Census Bureau–defined urbanized areas (urban areas are blocks or block groups with a minimum density of 1,000 people per square mile and surrounding blocks with a minimum density of 500 people per square mile). Any nonurban area was considered rural.[34]

Ulcer outcomes

We followed veterans first ulcer from their initial VA visit up to one year for the following outcomes: healed, amputated, died with active ulcer, unresolved ulcer at end of observation period, and lost to follow-up. If an ulcer did not heal within one year of first treatment, the outcome was considered "unresolved." If the ulcer resolution date was not stated in the chart but the ulcer was on a healing trajectory (e.g., decreasing size, evidence of granulation), the healed date was estimated as the date of the next visit when the ulcer was no longer mentioned, if this visit was within 6 months of the preceding ulcer treatment visit, or as the mid-point of the most recent visit and last visit, if more than 6 months elapsed.

Statistical analysis

Data management was conducted using SAS 9.2 (Cary, NC) and statistical analyses were conducted in STATA 12.1 (College Station, TX). Cox models were used to assess the impact of ulcer care components on ulcer healing as the main outcome for ulcers of each etiology. A hazard ratio above 1 implies improved chance of healing. A separate Cox model was created for each of the three ulcer types. Veterans with mixed etiology were included in analyses for all etiology groups to which they were assigned. All models included rural status; age at presentation of first study ulcer; smoking status; and history of coronary artery disease (CAD), lower limb ulcer, lower limb amputation, and moderate to severe renal disease.

The Cox model for *venous ulcers* assessed whether the following EB care components were performed in at least 80% of visits: edema assessment, moist wound healing, and infection assessment. The model also included a continuous variable documenting the percent of visits when edema was present and was treated. As there were too few visits where edema was both assessed by the provider and treated, we could not create a separate variable for edema treatment. In addition to the common variables noted above, the venous ulcer model was adjusted for history of PAD and diabetes presence/control.

The Cox model for veterans with *arterial ulcers* included binary indicators of ischemia assessment at first visit, if infection was assessed in at least 80% of visits, and whether a vascular surgery consult occurred within 30 days of ulcer presentation. The arterial ulcer model also included adjustment for diabetes presence/control. We did not adjust for history of PAD in this model as we presumed that all veterans with this type of ulcer had underlying arterial disease, regardless of prior diagnoses.

The Cox model for veterans with *DFU/neuropathic ulcers* included binary indicators of whether sharp debridement, moist wound healing, infection assessment, and offloading were performed in at least 80% of visits. The model included adjustment for history of PAD and diabetes control. We did not adjust for diabetes diagnosis in this model.

For each model, we tested to see if the proportional hazards assumptions for the Cox model were satisfied. We used the Multiple Imputation by Chained Equations (MICE) method to impute missing values, specifically: 6 missing BMI, 1 history of lower leg ulcer, and 12 history of smoking values. Factors used to predict these values were history of diabetes, PAD, CAD, age at ulcer onset, previous lower limb amputation, congestive heart failure, and renal disease. We used 10 simulated datasets to impute the data.

RESULTS

There were 224 veterans from the parent study with venous, arterial, or DFU/neuropathic ulcer etiology and mixed ulcer etiologies who were included in this study: 78 venous, 57 arterial, and 98 DFU/Neuropathic as shown in Figure 1.

Table 2 shows most veterans were white males in their mid to late 60s. Health history findings across ulcer groups showed a higher prevalence of diabetes and metabolic syndrome and sensory

neuropathy among those with DFU/neuropathic ulcers; a higher prevalence of PAD, CAD, MI, CHF, prior amputation, immobility and smoking in the arterial ulcer group; and a higher prevalence of venous insufficiency and BMI > 30 among those with venous ulcers. Table 3 shows the proportion of veterans with venous, arterial, and DFU/neuropathic ulcers who had a history of diabetes as 47%, 70%, and 89%, respectively. Table 3 also shows ulcer outcomes at 12 months. Among the various ulcer etiologies, diagnosed diabetes was present in 47% with venous ulcers, 70% in afterial ulcers and 90% in diabetic and neuropathic ulcers. At 1 year of follow-up, 72% of venous ulcers, 53% of arterial ulcers, and 75% of DFU/neuropathic ulcers had healed. The highest proportion of amputations occurred in veterans with arterial ulcers (23%) followed by veterans with DFU/neuropathic ulcers (15%) and veterans with venous ulcers (1%). The highest proportion of deaths was in the arterial ulcer group (12%). After one-year follow-up, the highest proportion of unhealed ulcers was in the venous ulcer group (18%).

Table 2. Demographic and health characteristics of veterans with chronic lower limb ulcers in VISN 20 from October 1, 2006 to September 30, 2007 ($n = 224$)

Variable	Category	Veterans with venous ulcer ($n = 57$)[a]	Veterans with arterial ulcer ($n = 78$)[a]	Veterans with DFU/Neuropathic ulcer ($n = 98$)[a]
Age at first study ulcer presentation Mean	–	67	69	64
Sex,%	Male	100	98	99
Race,%	White	65	60	67
	African American	3	5	6
	Other/Missing	31	35	27
Residence, %	Rural	55	44	48
	Urban	45	56	52
Medical history (condition(s) diagnosed before ulcer onset), %	Metabolic syndrome	71	61	82
	Diabetes	47	70	90
	Sensory neuropathy	33	70	85
	Charcot neuroarthropathy	0	0	6
	Peripheral arterial disease (PAD)	31	95	31
	Venous insufficiency	49	18	7
	Hypertension	83	89	85
	Coronary artery disease (CAD)	42	60	35

Variable		Category	Veterans with venous ulcer (*n* = 57)[a]	Veterans with arterial ulcer (*n* = 78)[a]	Veterans with DFU/Neuropathic ulcer (*n* = 98)[a]
		Myocardial infarction (MI)	15	33	13
		Congestive heart failure (CHF)	31	37	20
		Cerebrovascular disease	10	33	17
		Moderate or severe renal disease	19	23	16
		Cancer	10	21	9
		Immobility history (current or former)	31	56	26
		Lower limb surgery within 60 days of index visit	0	23	13
Lower limb history, %		Traumatic lower limb injury	20	11	17
		Prior lower limb ulcer	68	62	66
		Amputation	10	39	34
Lifestyle, %	Smoking history	Current or former	68	82	37
	Body mass index (BMI)	Baseline body mass index (BMI) ≥ 30.0	76	25	60
	Hemoglobin A1c	Baseline > 7.0% among people with diabetes	58	49	69
Laboratory values, %	Serum creatinine	Baseline ≥ 1.0	67	37	70
	Estimated glomerular filtration rate	Baseline < 60	35	37	30

a Veterans can fall into more than one ulcer etiology columns because 6 veterans had mixed arterial-venous ulcers and 3 veterans had mixed DFU-arterial ulcer.

Table 3. Chronic ulcer frequency and outcomes in VISN 20 veterans at 12 months follow-up

Ulcer frequency and outcomes at one year of follow-up	Venous ulcers $N = 78$[a] (47% had diabetes)	Arterial ulcers $N = 57$[a] (70% had diabetes)	DFU/neuropathic ulcers $N = 98$[a] (90% had diabetes)
Healed *n* (%)	56 (72)	30 (53)	73 (75)
Amputated *n* (%)	1 (1)	13 (23)	15 (15)
Death *n* (%)	6 (8)	7 (12)	3 (3)
Unresolved *n* (%)	14 (18)	6 (10)	7 (7)
Loss to follow-up *n* (%)	1 (1)	1 (2)	0 (0)

- a Veterans can fall into more than one ulcer etiology columns because 6 veterans had mixed arterial-venous ulcers and 3 veterans had mixed DFU-arterial ulcer.

Components of evidence-based ulcer care and ulcer healing

Among veterans with a venous ulcer, 20% had edema assessment or moist wound healing elements in at least 80% of their visits. However, sharp debridement was not performed on at least 80% of visits for any veteran with venous ulcer, thus this variable was excluded from further venous ulcer components of care analysis. There was a significantly higher chance of healing among veterans receiving edema assessment on at least 80% of visits (Hazard Ratio [HR] = 3.20, 95% Confidence Interval (95%CI): 1.34–7.66, $p = 0.009$) and infection assessment on at least 80% of visits (HR = 3.54, 95% CI 1.42–8.79, $p = 0.006$) (Table 4).

Table 4. Chronic ulcer healing and evidence-based ulcer care in VISN 20 veterans

Ulcer etiology model	Ulcer care component	Percent veterans receiving treatment at specified threshold[a]	Cox hazard ratio for healing	95% confidence interval	*p* value
Venous ($N = 78$)[b]	Edema assessment at ≥80% of visits	20	3.20	1.34−7.66	**0.009**
	Moist wound healing at ≥80% of visits	20	0.50	0.18−1.42	0.192
	Infection assessment at ≥80% of visits	23	3.54	1.42−8.79	**0.006**
	Percent visits with edema treated when edema was present		1.00	0.99−1.01	0.907

Ulcer etiology model	Ulcer care component	Percent veterans receiving treatment at specified threshold[a]				Cox hazard ratio for healing	95% confidence interval	*p* value
Arterial ($N = 57$)[c]	Sharp debridement at ≥80% of visits	0						
	Ischemia assessment at first visit	56				1.40	0.57−3.28	0.489
	Encounter with vascular surgery within 30 days of ulcer onset	39				1.91	0.73−5.0	0.191
	Infection assessment at ≥80% of visits	32				2.10	0.80−5.43	0.135
DFU/Neuropathic ($N = 98$)[d]	Debridement at ≥80% of visits	19				2.50	1.1-5.8	**0.032**
	Moist wound healing at ≥80% of visits	19	0.65	0.28−1.5	0.329			
	Offloading at ≥80% of visits	13	2.0	0.79−4.9	0.144			
	Ischemia assessed at first visit	50	2.0	1.0−3.9	**0.045**			
	Infection assessed at ≥80% of visits	51	0.80	0.41−1.6	0.509			

- Values in bold are statistically significant.
- a Percent veterans with the specific ulcer etiology for whom listed component of ulcer care was achieved.
- b Model also included: rural status; age at first study ulcer presentation; smoking status; and history of PAD, CAD, diabetes, lower limb ulcer, lower limb amputation, and moderate to severe renal disease.
- c Model also included: rural status; age at first study ulcer presentation; smoking status; and history of CAD, diabetes, lower limb ulcer, lower limb amputation, and moderate to severe renal disease.
- d Model also included: rural status; age at first study ulcer presentation; smoking status; and history of PAD, CAD, lower limb ulcer, lower limb amputation, and moderate to severe renal disease.
- Among veterans with arterial ulcers, 32% had infection assessment in at least 80% of visits, 56% had ischemia assessment on the first visit, and 39% had a vascular surgery evaluation within 30 days of ulcer presentation. All arterial ulcer care HRs were above 1 but not statistically significant (Table 4).

- Among veterans with DFU/neuropathic ulcers, 19% had sharp debridement, 19% had moist wound healing, 50% had infection assessment, and 13% had offloading performed on at least 80% of visits. In addition, 50% were assessed for ischemia at first visit. The resultant likelihood of healing with sharp debridement was 2.5-fold higher than in those not receiving sharp debridement at this frequency (95% CI: 1.10–5.80, $p = 0.03$). Ischemia assessment at the first visit doubled the likelihood of ulcer healing (HR=2.0, 95% CI: 1.0–3.9, $p = 0.045$). Three remaining ulcer care components were not significantly associated with ulcer healing (Table 4).
- Treatment of ulcer care components across all ulcer groups was similar between rural and urban settings (data not shown). The only component with significant impact on healing that was performed differently among rural and urban settings was edema assessment; 35% of rural versus 11% of urban veterans received this component in at least 80% of visits ($p = 0.016$).

DISCUSSION

The major finding of this study is that components of EB ulcer care were not consistently performed for the majority of VISN 20 veterans with chronic LLU, regardless of ulcer etiology or rural and urban status. While EB ulcer care guidelines do not currently specify the frequencies for performing components of EB ulcer care, we set 80% of visits as a satisfactory threshold for ulcer care components based on the study by Olson and associates on venous ulcer healing. Unlike Olson and associates, we found that very few veterans received combination of all EB ulcer care components in at least 80% of their visits. Therefore, we were unable to analyze the impact of all EB ulcer components performed at this level. This may reflect the differences in setting and veteran populations between the two studies. The Olson and associates study involved primarily urban veterans receiving care at two multidisciplinary tertiary care centers while our study included veterans receiving ulcer care across VISN 20 rural and urban clinics.

As hypothesized, among veterans with *venous ulcers,* we observed that both edema and infection assessment on at least 80% of visits significantly improved the chance of healing. We were unable to assess the association between debridement performance and healing as debridement of venous ulcers was done so infrequently. For *DFU/neuropathic ulcers*, sharp debridement had the greatest impact on healing when performed on at least 80% of visits. This was followed by ischemia assessment at first visit, thus emphasizing the importance of these two care components in the management of DFU/neuropathic ulcers. Other ulcer care components across the three ulcer types were not significantly associated with healing.

In this study among venous ulcer patients, increasing the proportion of visits where edema was treated with compression therapy had no effect on venous ulcer healing (HR = 1.00, 95% CI: 0.99–1.01, $p = 0.680$). Two reasons for this could be the lack of power to detect this relationship due to the sample size and poor patient compliance with compression therapy. A large study on patient compliance with prescribed compression therapy reported that 63% of patients with chronic venous disease did not use compression stockings or devices at all, 21% used them on a daily basis, and the rest used them inconsistently.[35]

The VA recognizes the impact of chronic lower limb ulcers on function, quality of life, and healthcare cost. The VHA developed multidisciplinary programs such as High Risk Foot Clinics and Prevention of Amputation in Veterans Everywhere (PAVE) Program teams to prevent or delay amputations through proactive identification of patients at risk of limb loss. Our results suggest that improving guideline-concordant care across all wound care settings, for example to a target of 80%, could improve wound outcomes.

This study had several limitations. We defined debridement as sharp debridement which is considered the gold standard in wound care, thus excluding enzymatic and mechanical techniques.[2, 3, 36] These additional means of debridement were included in Olson and associates and could explain why we did not see higher levels of debridement for venous ulcers. It is important to note that the group analyzed as DFU/neuropathic ulcers included six purely neuropathic ulcers in patients with no history of diabetes. Though there are no separate treatment guidelines for neuropathic ulcers, these ulcers may have different healing trajectories due to lack of diabetic pathology and therefore may have influenced the results obtained. Another study limitation was our inability to adjust for ulcer size and depth at the presentation due to frequent missing values. This could have confounded the relationship between EB ulcer care and healing.[37] Our sample size may not have been large enough to detect association between some of the ulcer care components and healing.

The study strengths included broad geographic diversity of ulcer patients. Studies show that rural veterans have reduced access to specialty providers, which could impact the quality of healthcare they receive.[38] In our literature review we did not find chronic ulcer care studies that actively recruited rural patients. Our parent study population consists of 50% rural veterans to assess quality of ulcer care in both rural and urban settings.

In summary, we found that evidence-based ulcer care is not optimal for Pacific Northwest veterans. Our data indicate that the low frequency of guideline-concordant care may be contributing to poor chronic lower limb ulcer outcomes. Therefore, providers of lower limb ulcer care need to address the components of ulcer care associated with improved ulcer outcomes, namely edema and infection assessment for venous ulcers and sharp debridement and ischemia assessment on first visit for DFU/neuropathic ulcers.

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