Rural Residence, Dual System Healthcare Use, and Chronic Wound Utilization and Outcomes among Northwest Veterans

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Abstract

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As the prevalence of diabetes and peripheral artery disease rise, chronic lower limb wounds are an increasingly important public health issue. These wounds can impair mobility and reduce quality of life. We were interested in how two common Veteran characteristics, rural residence and dual system health care use, influenced wound care treatment and outcomes. Veterans living in rural areas typically have poorer health and lower health care utilization than urban Veterans and we hypothesized that wound healing would be lower among rural Veterans. Veterans who use the Veterans Health Administration (VHA) for health care also may be eligible for Medicare and may receive care outside of VHA. We hypothesized that dual system (VHA and Medicare) wound care use would result in fragmented care and therefore poorer wound healing than VHA-exclusive use. To test our hypotheses, we assembled a cohort of 160 rural

and 160 urban VHA users in the Pacific Northwest with incident chronic (≥30 days) lower limb wounds between October 1, 2006 and September 30, 2007 and followed them for one year. We used Poisson models with robust standard errors to compare outpatient and inpatient wound care utilization. We used proportional hazards models to estimate the hazard ratio (HR) of wound healing, accounting for the competing risks of amputation and death, and adjusting for confounding by various factors based on the literature. Rural Veterans had lower outpatient wound care utilization (mean 6.8 versus 9.9 visits) and a similar hazard of wound healing (HR=1.11, 95% CI: 0.84-1.47, p=0.45) compared to urban Veterans. 71% of the cohort was enrolled in Medicare but only 13% of cohort members were dual system wound care users. Dual users had significantly higher observed utilization (mean 11.6 outpatient visits and 1.7 inpatient stays compared to 7.5 and 0.7, respectively) and a lower hazard rate of wound healing compared to VHA-exclusive users (HR=0.38, 95%CI: 0.25-0.56, p<0.001). Additional research is needed to replicate our findings and to understand the mechanisms underlying the differences in utilization and outcomes and to identify interventions to further improve wound healing among Veterans, particularly dual users.

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CHAPTER 1. INTRODUCTION

The Veterans Health Administration (VHA) serves more than 6 million Veterans each year, many of whom are age 65 or older and have multiple chronic health conditions (1-3). An estimated one in four Veterans has been diagnosed with diabetes (4). These chronic conditions must be managed by Veterans in consultation with their health care providers in order to prevent exacerbations or complications. Veterans with diabetes, sensory neuropathy, and peripheral artery disease are particularly vulnerable to the development of skin wounds on the lower limbs (LL) (5). This dissertation aims to assess wound care treatment and outcomes among Veterans who receive health care through VHA, focusing on factors related to their health care utilization, namely rural residence and the use of non-VHA health care systems. The text is organized into a brief introduction to the relevant issues below, followed by two chapters that address the characteristics of rural and urban Veterans and Veterans who use both VHA and Medicare for wound care and how wound outcomes vary for these groups of Veterans, and a final summary of findings.

Chronic Wounds & Treatment

Chronic wounds are those that fail to progress as expected through the phases of healing. Typically, they stall in the initial inflammation phase or in the proliferation phase before progressing on to the final maturation phase of healing (5). Chronic wounds cause disability and impact disease burden, quality of life, and health care costs for thousands of Veterans annually (6-8). Although around 70% of chronic wounds will heal within a year, longer healing times increase the potential for infection and amputation (6-8). Therefore, facilitating

rapid wound healing is an important approach to preserving the health and quality of life of Veterans.

While much of the biology and individual treatment of wounds is well understood, less is known about the features of wound care organization and delivery that could improve wound outcomes and accelerate wound healing. Therefore, understanding wound care utilization for rural Veterans and Veterans who use VHA and Medicare and the relationship to wound outcomes is important. Several studies have reported high rates of healing in comprehensive wound clinics led by specialists and staffed by experienced wound care teams (9), but little research has focused on non-specialty settings like primary care or urgent care clinics or integrated health care systems like VHA. Administrative VHA data indicate that half of lower limb wounds are treated in primary and secondary care facilities, while most wound care specialists are at tertiary care centers. Wound care treatment covered through Medicare also varies widely and may be completed by primary care providers, wound care centers, or tertiary care facilities. Neither VHA nor Medicare have their own guidelines for chronic wound management, but each has specific services (e.g., debridement) and items (e.g., wound dressings) related to wound care treatment it allows, either through inclusion on its formulary (VHA) or through provider reimbursement (Medicare).

Rural Veterans: Health and Treatment

The overall physical and mental health of rural Veterans has been reported to be poorer than the health of their urban peers (10-13). Living in a rural area creates barriers to accessing health care. Across studies and settings, rural residents report that transportation, time, and

cost prevent them from seeking medical care (10, 14-17) and data show that rural Veterans use fewer health care services than their urban peers (18).

Beyond these health and health care organization-related differences, personal and environmental factors including income, beliefs, and behaviors may be encompassed by the label "rural." For example, rural Veterans may live alone more often than urban Veterans and may have less connected social networks. Although not measured in this study, these characteristics could reduce the availability of caregivers or reflect a feeling of independence among rural Veterans that may lead to poorer wound outcomes based on their inability or unwillingness to obtain assistance with wound care or to travel to a health care provider for regular wound care.

Studies that assess health care utilization tend to show that rural Veterans have lower utilization compared to their urban peers. For example, Cully and colleagues found that rural Veterans newly diagnosed with a mental health condition were about half as likely as their urban peers to receive either 4 or 8 psychotherapy sessions (19). Utilization tends to be lower for specialty care treatment in particular. Turner et al. found that rural Veterans with multiple sclerosis were 20% less likely to have a specialty care treatment visit than comparable urban Veterans (20) and Abrams and colleagues, in a retrospective cohort study of more than 15,000 VA hospital admissions for acute myocardial infarction, found that rural Veterans were less likely than urban Veterans to undergo revascularization (21). In all of these studies, only VHA care was included so it is possible that some of the patients received the treatment of interest outside the VHA. To date, studies that go beyond describing differences in utilization to compare the health outcomes of rural and urban Veterans are sparse.

Veterans & Dual Use

VHA prioritizes access to its services based on Veterans' service-connected disability (SCD) rating and income (22). Thus, the ability of Veterans to see a provider and the required copayment for services often is influenced by their priority level. Veterans with lower priority may use private insurance for care or may use another federal program like Medicaid, Medicare, or Indian Health Service, if they are eligible. Individuals who use more than one health care system or payer are referred to as "dual users."

In theory, dual use could benefit Veterans by offering expanded options for care, such as specialty services or medications not available through VHA. To date, however, most evidence suggests that the use of multiple health care systems is associated with poorer health outcomes (23-24). This could be because dual users have a higher burden of health conditions that lead to the higher utilization and poorer health outcomes. Alternatively, it could be that dual use results in fragmented care and poor communication between providers in different systems. Few studies have assessed the impact VHA-Medicare dual use on health outcomes specifically.

Motivation for the Dissertation

Currently, a gap in the literature exists related to chronic wound care and outcomes among Veterans. Therefore, this dissertation aims to assess wound care treatment and outcomes among rural and urban Veterans and among Veterans who use VHA exclusively and those who use VHA in combination with Medicare for wound care. Only in recent years has it been possible to merge Veteran health care data from VHA and Medicare. In the studies that comprise this dissertation, we take advantage of this opportunity to more accurately quantify

wound care across these two major systems. We describe both the quantity of various types of wound care utilized within VHA and Medicare and the association between wound healing and Veteran characteristics, namely rural residence and dual Medicare-VHA use. The results of these studies will inform us of potential disparities in wound outcomes based on rural residence or of negative effects associated with multi-system use.

CHAPTER 2. CHRONIC WOUND CARE TREATMENT AND OUTCOMES AMONG RURAL AND URBAN VETERANS

Abstract

Veterans in rural areas generally have lower health care utilization than Veterans in urban areas, though the impact of this difference on health outcomes has been infrequently explored. The goals of this study were to describe chronic wound care among rural and urban Veterans and to measure the association between rural residence and wound healing. We conducted a retrospective cohort study of 160 urban and 160 rural Veterans in the Pacific Northwest who had at least two visits within the Veterans Health Administration (VHA) for an incident chronic lower limb wound between October 1, 2006 and September 30, 2007. We followed wounds for up to one year, measuring outpatient and inpatient wound care utilization within VHA and Medicare. We compared utilization using Poisson regression models with robust standard errors and we compared wound healing using a competing risks proportional hazards model accounting for amputation and death. Overall, rural Veterans had fewer outpatient wound care visits than urban Veterans. Inpatient utilization was low and similar for rural and urban Veterans. During follow-up, 234 Veterans' wounds healed (77% of rural and 69% of urban). The adjusted hazard ratio for wound healing was 1.11 (95% CI: 0.84-1.47, p=0.45) for rural compared to urban Veterans. Rural Veterans had lower wound care utilization and their wounds were as likely to heal as urban Veterans' wounds. However, amputation was more common among rural Veterans (HR=2.65, 95% CI: 1.02-6.87, p=0.045) and 50% of rural Veterans versus 9% of urban Veterans had a transtibial or transfemoral amputation.

Background

Chronic lower limb wounds represent an important public health issue; they contribute to disability and reduce quality of life annually for thousands of individuals in the US (6-8, 25-28). Chronic wounds also are a major cause of lower limb amputations, many of which might be prevented if appropriate prevention and treatment interventions were accessed (29-32). Veterans living in rural areas use fewer health care services than their urban counterparts (18). Across VHA studies and settings, rural residents report that transportation, time, and cost prevent them from seeking medical care (14-17, 19). Rural Veterans also receive less specialized care than urban Veterans (20, 33-34). Together, this lower wound care utilization and, in particular, lower utilization of specialty wound care might lead to poorer wound outcomes among rural Veterans than among their urban peers.

Veterans in rural areas generally have poorer physical and mental health, as measured by the number of health conditions or health-related quality of life, than Veterans living in urban areas (10-13, 35). Studies comparing specific health outcomes of rural and urban Veterans are sparse and a number have found no differences between rural and urban Veterans. For example, Egede et al. found no difference in diabetes control, as measured by hemoglobin A1c among rural compared to urban Veterans (36). In two studies of mortality, investigators found similar mortality rates for rural and urban Veterans (21, 37), while in a third, mortality was higher for isolated rural Veterans but there was no difference between non-isolated rural and urban Veterans (38).

No previous studies have compared utilization and outcomes for chronic wounds among rural and urban Veterans. The goals of this study were to describe wound care utilization among rural and urban Veterans and to measure the association between rural residence and

wound healing within the VA healthcare system (VHA). We hypothesized that rural Veterans with chronic wounds would have lower wound care utilization and less specialty care, consistent with previous studies. We expected to observe lower rates of wound healing for rural Veterans than their urban peers.

Methods

This study was conducted in the VA's Northwest Health Network, VISN 20, and was reviewed and approved by the VA Puget Sound Health Care System's Human Studies Subcommittee (IRB #00253).

In order to be included in the study, an open wound on a Veteran's lower limb (LL) must have been treated for at least 30 days. This 30-day minimum is based on the Medicare definition of a chronic wound (39). The date of the first VHA wound treatment visit was considered the baseline date. We followed all wounds for one year after baseline or until wound healing, amputation, or death. For each Veteran, we included only the first wound that met inclusion criteria. We used the VHA's computerized patient record system to collect all health history and wound care-related variables. We supplemented VHA treatment information with Medicare administrative files to capture wound care visits reimbursed through Medicare fee-for-service coverage.

To define urban and rural residence, we used the VA classification system used during the study period, which was based on United States Census Bureau-defined Urbanized Areas. Specifically, Census 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 were considered urban. Any non-urban area was considered rural.

Subject Selection

We used a set of 42 high-probability ICD-9 codes enumerated in previous studies (40-41; Appendix A) to identify Veterans with at least one outpatient VHA encounter related to a LL wound between October 1, 2006 and September 30, 2007. We assigned all VISN 20 Veterans with one of these codes to either urban (n=3,220) or rural (n=1,818) residence based on the address in the VHA administrative data file at the time of their latest outpatient visit in fiscal year 2007 with one of the ICD-9 codes of interest. We then screened potential subjects until we identified 160 rural and 160 urban Veterans who met inclusion criteria (Appendix B). Sample size (n=320) was calculated based on the primary outcome time to healing with 0.80 power and 0.05 probability of a Type I error to detect a hazard ratio of 1.5 or greater. For this power calculation, we also assumed 60% of the pooled sample would have an event (heal) during the study period and that the healing curves would follow an exponential distribution.

Inclusion and Exclusion Criteria

Chronic LL wounds had to be treated during at least two VHA visits, at least one of which had to be an outpatient visit, to be included in the study. We did not restrict the etiology: wounds could have been caused by acute trauma, chronic pressure, infection, or underlying health conditions. Veterans with no chronic LL wounds in the study period (n=544), Veterans who began receiving treatment for a chronic LL wound before the study period (not incident during the study period; n=120), Veterans whose LL wounds were not chronic (<30 days of treatment; n=439), Veterans who died within the first 30 days of wound treatment (n=7), Veterans who had the wound site amputated within the first 30 days of wound treatment (n=11), and Veterans who had no outpatient visit (n=31) or fewer than two total wound-related

VHA visits (n=28) were excluded from the study. Exclusion reasons were similar for rural and urban Veterans. We reviewed 782 rural Veterans' and 718 urban Veterans' charts to achieve the desired sample size.

Wound Characteristics and Resolution

For each wound, we recorded the location and etiology. We determined etiology based on ICD-9 diagnosis codes and VHA provider chart notes. Etiologic categories were arterial, diabetic, neuropathic, venous, pressure, infectious, and other (e.g., burns or trauma or dermatologic conditions). If providers indicated more than one underlying factor substantially contributed to the wound's etiology, we classified the wounds as mixed etiology. At baseline, we recorded whether complex anatomy was present at the wound site, which included the presence of hardware or physical conditions like hammer toe, Charcot foot, or a previous amputation. We also recorded whether the wound showed exposed bone, tendon, or joint, or whether there was evidence of osteomyelitis at baseline.

The wound was considered healed at the visit when a provider documented it had completely re-epithelialized or healed. If no healing was documented but the wound was on a healing trajectory, we recorded the healed date as the date of the next visit if within 6 months of the preceding wound treatment visit, or as the midpoint between visits if the next visit was more than 6 months later. Wounds had to remain closed for at least 30 days to be considered healed. Veterans who were lost during follow-up were censored at their last VHA wound care visit.

Wound Care Visits and Providers

As noted above, we used chart notes to assess VHA care and Medicare administrative files to measure Medicare-financed care. The content and structure of these data differ, so we used different methods to identify wound care visits within each system. For care delivered through VHA we recorded the date and provider type for each outpatient visit at which the wound was assessed (i.e., dressings removed) and treated based on chart documentation. Within Medicare, we included all outpatient visits with one of the 42 ICD-9 codes originally used to identify study subjects. We excluded fee basis and home health care visits from this study.

In both systems, we classified provider type as non-specialist (primary care, internal medicine, or emergency medicine provider), wound specialist (podiatry, vascular surgery, orthopedic surgery, plastic surgery, dermatology, physical medicine and rehabilitation, infectious disease, or certified wound care nurse), and non-wound specialist (e.g., cardiology, oncology). In VHA, we used information from the medical record note to classify provider type. In Medicare, we used the provider's specialty code, either available directly in the dataset or identified using the provider's National Provider Index (NPI) number, to classify provider type.

We abstracted information about inpatient stays in hospitals or skilled nursing facilities from both systems. Within VHA, we relied on chart notes from providers treating patients in the hospital or in a skilled nursing facility to identify stays. Within Medicare, we used the same set of ICD-9 codes referenced above and counted the number of unique inpatient and skilled nursing stays within Medicare. In both systems, if a patient was transferred from one facility to another we counted two unique stays.

Baseline Health and Covariates

We collected information from the VHA medical record about the Veteran's age, gender, marital status, type of residence, and health status and health history at the baseline visit. We used Medicare (denominator file) to classify Veterans' race and ethnicity; if a Veteran was not enrolled in Medicare we abstracted the information from the VHA record. We categorized age as under 50, 50-59, 60-69, 70-79, and 80 and older. We recorded the Veteran's race as white, black, Asian, Native American/Alaska Native, Hispanic, other, or unspecified. We recorded where Veterans lived at baseline and classified residence as living in a single family home versus not (living in an assisted living facility or skilled nursing facility, being homeless, or residence unknown). We also recorded marital status in several categories based on VHA records and categorized it as married versus not (separated, widowed, divorced, or single) since we were interested in accounting for the presence of someone who might provide support or assistance for wound care in the adjusted analyses.

We used physician comments in VHA progress notes or the "Problem List" available in the medical record to assess whether or not the Veteran had each of the following chronic health conditions or events at baseline: diabetes, peripheral artery disease, hypertension, congestive heart failure, coronary artery disease, myocardial infarction, cerebrovascular disease, renal insufficiency or renal disease, liver disease, lower limb paralysis, connective tissue disease (e.g., rheumatoid arthritis, lupus), cancer, and HIV/AIDS. To adjust for baseline comorbidity, we summed the number of these conditions present at baseline and added an additional point if the Veteran had a diabetes-associated complication (sensory neuropathy, renal disease, or retinopathy), similar to the Charlson-Deyo comorbidity index (42). The maximum possible comorbidity score was 14. Also, we created a categorical variable to

describe Veterans' lower limb history: having neither a previous LL wound nor LL amputation, having a previous LL wound without amputation, or having a previous LL amputation (with or without a previous LL wound).

We recorded whether or not the Veteran had an established VHA primary care provider at baseline (yes versus no). We also recorded Veteran's service connected disability (SCD) rating, which represents the average impairment in earning capacity resulting from a disease or injury related to a Veteran's military service (43). Within VHA, Veterans with a SCD rating of 50% or higher are eligible for free care for the condition (including inpatient, outpatient, and pharmacy); Veterans with a SCD rating of 0-40% may be eligible for free care if they are low income (22). We classified Veterans as having a 50-100% SCD rating or not. We considered Veterans to be dual Medicare-VHA users if they had at least one inpatient or outpatient visit with a wound-related ICD-9 code in the Medicare file during follow-up.

Sensitivity Analyses

We planned three sensitivity analyses *a priori*. First, we analyzed data using a 60-day minimum wound duration rather than the 30-day minimum based on the Medicare definition (n=43 wounds <60 days; 23 rural and 20 urban). Second, we considered whether the method of assigning the healed date for Veterans with long intervals between the last treatment visit and the healed date influenced our results. Rather than using the midpoint between dates, we changed the healed date to 30 days after the last treatment visit for those Veterans whose healed visit was more than 6 months after the last treatment visit and whose wound was on a healing trajectory (n=19; 15 rural and 4 urban). We chose 30 days because most Veterans in the study were seen at least once a month while their wound was active and, among Veterans

with healed visits close to the last treatment visit, many occurred around 30 days apart. Finally, during the study period, the Walla Walla VAMC, which serves a largely rural area, was conducting an intervention to improve wound care and therefore may have provided different wound care than other sites during the study (40-41). Our third sensitivity analysis excluded Veterans who received care at the Walla Walla VA (n=19; all rural) to determine how much this concurrent intervention affected the results of this study.

Data Analysis

To describe the sample, we calculated proportions and 95% confidence intervals (CI) for demographic and health status variables by rural/urban status. To describe wound care utilization, we calculated the number of outpatient visits with each provider type and the number of inpatient stays within VHA and within Medicare for each person. We then calculated the mean number of each visit/stay type per person and report those means. To examine whether utilization varied across rural and urban Veterans, accounting for potential confounding variables, we used Poisson regression models with robust standard errors (RSE) (44). For the outpatient model, we used a zero-truncated model (45) since we required that all subjects have at least one outpatient visit to be included in the study. We used plots of observed and predicted counts, residual plots, and a goodness-of-fit chi-square test to assess whether the Poisson model fit the data. We considered whether dual use of VHA and Medicare modified the association between rural residence and utilization and used an *a priori* p-value of <0.10 for the interaction term to indicate statistical significance.

To assess the association between rural residence and wound healing, we used a competing risks proportional hazards model that accounted for the competing risks of amputation and death (46). Hazard ratio (HR) estimates represent the estimated hazard ratio for wound healing, comparing a group of interest (e.g., rural Veterans) to a reference group (e.g., urban Veterans). Because our chronic wound definition required 30 days of treatment without healing, amputation, or death, we excluded the first 30 days of follow-up from our competing risks analysis to reduce bias. We assessed the proportional hazards assumptions for the model using Schoenfeld residual plots for each variable included in the model and we used delta beta plots to identify influential subjects (46). We adjusted for sociodemographic, baseline health, and wound characteristics associated with wound healing based on existing literature (30, 47-50) but did not include factors highly correlated with rural residence in the models, such as income or distance to VHA facilities, to avoid adjusting away the effect of rural residence itself (51). Four Veterans were missing a hemoglobin A1c value at baseline; because none of these Veterans had a history of diabetes we classified them as having an A1c value less than 7.0 for the comorbidity score calculation. There were no missing data for other variables included in the proportional hazards model. We used cumulative incidence curves to describe overall time to healing for subgroups of interest defined by rural status (46, 52). All analyses were completed using STATA 12.1 (College Station, TX).

Results

Sample Characteristics

The majority of Veterans included in this study were male (98%; Table 1) and the mean age at first wound treatment was 66 years. Most Veterans were white and lived in their homes; about half were married. Rural Veterans more frequently had peripheral artery disease and coronary artery disease at baseline than urban Veterans, while urban Veterans had a higher prevalence of diabetes (no statistical tests done for differences). The average summed comorbidity score was 3.9 (SD=2.4) among rural Veterans and 3.6 (SD=2.2) among urban Veterans. Half of rural Veterans and 67% of urban Veterans had a previous LL wound and 24% and 27%, respectively, had a LL amputation at baseline. Other characteristics were similar across rural and urban Veterans.

Wound Characteristics

The characteristics of study wounds were similar across rural and urban Veterans (Table 2). About half of all wounds occurred below the ankle, with the heel or plantar surface of the foot (e.g., metatarsal heads) being the most frequent wound location for both rural (22%) and urban (25%) Veterans. A small proportion of all wounds were at the site of a previous amputation (6% of rural and 9% of urban Veterans' wounds). Wound etiology was similar for rural and urban Veterans, with diabetic (30-31%), venous (21%), and arterial (13-17%) wounds occurring with the highest frequency. A small number of wounds were classified as mixed etiology (4% of rural and 6% of urban). At baseline, about 31% of Veterans had complex anatomy at the wound site and approximately 8% of Veterans had a wound with exposed bone, tendon, or joint.

Wound Care Utilization

The mean number of non-specialty VHA outpatient visits per person was similar for rural and urban Veterans (Table 2); 59% of rural Veterans and 63% of urban Veterans had a non-specialty outpatient visit within VHA. Urban Veterans had an average of 6.9 VHA wound specialty visits per person while rural Veterans averaged 4.2 per person. Eighty-eight percent of both rural and urban Veterans had at least one VHA wound specialty visit. There were 22 rural Veterans (14%) and 19 urban Veterans (12%) who were classified as dual users. Within Medicare, non-specialty visits were more common than wound specialty visits. Rural dual users averaged 2.3 non-specialty and 1.1 wound specialty visit per person and urban dual users averaged 3.6 and 0.9, respectively. There were very few non-wound specialty outpatient visits within VHA and none in Medicare.

The mean number of VHA inpatient stays per person – both hospital and skilled nursing – was similar for rural and urban Veterans and was less than 1. About 38% of Veterans had an inpatient VHA stay and 12% of rural Veterans and 5% of urban Veterans had a VHA skilled nursing stay. Likewise, the number of Medicare hospitalizations was low. Among dual users, 36% of rural Veterans and 32% of urban Veterans had a Medicare hospital stay and 14% of rural Veterans and 21% of urban Veterans had a skilled nursing stay.

Overall, the mean number of outpatient visits was 6.8 for rural Veterans and 9.9 for urban Veterans, which was statistically significantly different ($p<0.001$) in an unadjusted truncated Poisson model. We found no evidence for an interaction between rural residence and dual use ($p=0.24$). After adjusting for age, age squared, number of comorbid conditions, dual use, SCD rating $\geq$50%, and time of follow-up, rural Veterans had significantly lower outpatient utilization compared to urban Veterans ($p<0.001$). When the covariates were set at their

means, the predicted number of outpatient visits was 6.3 (95% CI: 5.5-7.0) for rural Veterans and 8.3 (95% CI: 7.4-9.1) for urban Veterans. The mean number of total inpatient and skilled nursing stays per person was 0.9 among rural Veterans and 0.8 among urban Veterans, and there was no statistically significant difference in an unadjusted Poisson model (p=0.90). Again we found no evidence of an interaction between rural residence and dual use (p=0.76). In the adjusted analysis, there was no difference in the number of inpatient stays for rural and urban Veterans (p=0.96). Based on the model, the predicted number of stays was 0.7 (95%CI: 0.57-0.90) for rural Veterans and 0.7 (95%CI: 0.54-0.92) for urban Veterans. For both the outpatient and inpatient models, there was evidence that the models did not fit the data well based on the plots and a deviance goodness-of-fit chi-square test.

Wound Outcomes

During one year of follow-up, 234 Veterans' wounds healed (123 rural and 111 urban; 73%), 27 Veterans underwent amputation (16 rural and 11 urban; 8%), 20 Veterans died with the wound present (7 rural and 13 urban 6%), 5 Veterans were lost (2 rural and 3 urban; 2%), and 34 had ongoing wounds at the end of follow-up (12 rural and 22 urban; 11%). In the crude competing risks regression model, the estimated hazard ratio for wound healing comparing rural Veterans to urban Veterans was 1.20 (95% CI: 0.93-1.55, p=0.16). After adjusting for baseline health, demographic, and wound-related factors, the hazard ratio estimate moved closer to the null and rural Veterans had an estimated 11% higher hazard of wound healing during follow-up compared to their urban peers but the difference was not statistically significant (HR=1.11, 95% CI: 0.84-1.47, p=0.45; Table 3). The cumulative incidence curves for wound healing among rural and urban Veterans based on the adjusted competing risks model

appear in Figure 1. These curves demonstrate, like the hazard ratio estimate, that wound healing was similar for rural Veterans and urban Veterans after adjusting for potential confounding variables. The median time to healing was 131 (95%CI: 104-150) days for rural Veterans and 124 (95%CI: 105-135) days for urban Veterans.

The hazard ratio estimates for the two competing risks – amputation and death – also appear in Table 3. In the adjusted model, rural Veterans were significantly more likely than urban Veterans to undergo amputation during follow-up (HR=2.65, 95% CI: 1.02-6.87, p=0.045). There were 16 amputations among rural Veterans during follow-up and 11 among urban Veterans. Nine (56%) rural Veterans and three (27%) urban Veterans had a transtibial (below knee) or transfemoral (above knee) amputation; the remainder had toe or transmetatarsal amputations. Median time to amputation was 59 (95%CI: 39-207) days for rural Veterans and 76 (95%CI: 47-289) days for urban Veterans. Conversely, rural Veterans were significantly less likely than their urban peers to die with an active wound (HR=0.35, 95% CI: 0.12-0.97, p=0.043). Median time to death was 114 (95%CI: 51-174) days for rural Veterans and 126 (95%CI: 58-237) days for urban Veterans.

Sensitivity Analysis Results

In all sensitivity analyses, the point estimates for wound healing were similar to the estimates based on the full study sample. When we excluded Veterans with wound duration <60 days, the HR for wound healing comparing rural residents to urban was 1.07 (95% CI: 0.80-1.44, p=0.64). However, in the sensitivity analysis excluding Veterans with <60 day wound durations, the HR for amputation was estimated to be 2.99 but with poor model fit and no estimated confidence interval. The HR for death was 0.57 (95% CI: 0.14-2.23, p=0.42) and was

not statistically significantly different for rural and urban Veterans. When we moved the resolution date to 30 days after the last treatment visit, the HR for wound healing was 1.16 (95% CI: 0.88-1.53, p=0.30) and the HR estimates for amputation and death were 2.65 (95% CI: 1.02-6.86, p=0.045) and 0.35 (95% CI: 0.12-0.97, p=0.043), respectively. When we excluded Veterans who received wound care at the Walla Walla VA, the HR for healing was 1.09 (95% CI: 0.82-1.45, p=0.53), the HR for amputation was 2.27 (95% CI: 0.83-6.25, p=0.11), and the HR for death was 0.34 (95% CI: 0.11-1.01, p=0.052). Based on the sensitivity analysis in which we shortened the healed date for Veterans with a long follow-up period between the last wound treatment date and the wound healed date, our abstraction rule may have biased the results slightly in favor of urban Veterans since they had higher utilization and shorter times between appointments.

Discussion

Rural Veterans had lower outpatient wound care utilization than their rural peers but we found no significant difference in wound healing hazards between the two groups. These results are based on a random sample of Veterans utilizing the VHA in the Pacific Northwest for outpatient chronic wound care treatment and were not sensitive to the definition of a chronic wound (30-day versus 60-day minimum definition) or to a wound treatment intervention that was ongoing at one site during the study period. As expected, rural Veterans used less VHA specialty wound care than urban Veterans. This is consistent with a number of other studies that reported poorer specialty access for rural Veterans (18-20). Although we hypothesized that rural Veterans would experience poorer wound outcomes than their urban peers, our finding that wound outcomes were similar is consistent with several recent studies that found similar

mortality among rural and urban Veterans (21, 37-38). The VHA has worked to improve access to care for rural Veterans over the past decade, including the addition of community-based outpatient clinics in rural areas (51, 53). This expanded availability of primary care providers might explain the similarity in wound care outcomes observed in this study.

We found that rural Veterans were more likely to undergo amputation and less likely to die with a wound than urban Veterans; however these results were sensitive to excluding study subjects and need to be replicated in a sample with more events. Rural Veterans in the study more frequently had major amputations (at the transtibial or transfemoral level) than urban Veterans. We systematically reviewed the medical records of individuals who underwent amputation but did not identify any health system factors to explain the difference in amputation. For example, among rural Veterans who ultimately underwent amputation, all but one who saw a primary care provider at their first visit were referred to a specialist by their second visit; the other individual was seen by a specialist within a month. There is ongoing debate about the health and quality of life impacts of limb salvage versus amputation and whether all amputations can be prevented (54-58). The higher amputation rate among rural Veterans in the study corresponded to a lower hazard rate for mortality, so while amputation is a poor wound outcome it presumably is preferable to death for patients with chronic wounds. Patient factors or health system variables not measured in this study might explain the differences in amputation and death observed in this study.

This study has several limitations. First, our inclusion criteria required that Veterans utilize VHA for at least two wound care visits, one of which had to be an outpatient encounter. As a result, the study represents neither inpatient-only VHA users nor VHA users who use the

system very infrequently. Second, this study was powered to compare wound healing and the number of amputations and deaths was small. As a result, the estimates for these competing risks are accompanied by wide confidence intervals. Third, although we included an indicator of whether Veterans used Medicare for wound care during the study period and included fee-for-service Medicare wound care visits in the utilization measures, we did not include data from other non-VHA health systems in this analysis. Based on the VHA medical record, 25% of Veterans in the study had private insurance at the time of their wound (26% of rural Veterans and 24% of urban Veterans) but we do not know whether any subjects used their private insurance for wound care during follow-up. Finally, because of the differences between VHA and Medicare data structures, full VHA electronic medical record but Medicare billing claims only, we used different methods to identify wound care visits. Within VHA we reviewed all provider notes to determine whether wound care was provided while in Medicare we relied on ICD-9 codes to identify wound care visits.

Conclusion

More than one in three Veterans enrolled in the VHA system lives in a rural area (11, 51). A disproportionate number of troops who served in recent conflicts – Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) – were from rural areas, suggesting that a high proportion of Veterans will continue to live in rural areas in the future (11, 51). It is therefore important to assure that the quality and accessibility of care in rural and urban settings is equivalent and that rural Veterans are not at increased risk for poor health outcomes. Chronic wounds provide a model for studying access to complex chronic care since they often are related to underlying health conditions and may require lengthy treatment.

Based on these results, chronic lower limb wound care utilization was generally lower for rural Veterans, yet wound healing was similar for rural and urban Veterans who used VHA for outpatient care. Additional research is needed to replicate these findings and to understand whether patient factors or health system variables explain the higher rate of amputation and lower rate of death with active wounds among rural Veterans compared to their urban peers.

Table 1. Baseline demographic and health characteristics of rural and urban Veterans with chronic lower limb (LL) wounds.

Variable	Categories	Rural Veterans (n=160)		Urban Veterans (n=160)	
		%	95% CI	%	95% CI
Age (years)	Under 50	5.6	2.9-10.5	6.9	3.8-12.1
	50-59	23.1	17.2-30.4	31.3	24.5-38.9
	60-69	28.1	21.6-35.7	31.9	25.1-39.6
	70-79	25.0	18.8-32.4	18.7	13.4-25.6
	80+	18.1	12.8-24.9	11.3	7.1-17.2
Gender	Male	98.1	94.3-99.4	97.5	93.5-99.0
	Female	1.9	0.6-5.7	2.5	0.9-6.5
Marital status	Married	56.3	48.4-63.8	48.1	40.4-55.9
	Not married	43.7	36.2-51.6	51.9	44.1-59.6
Race/ ethnicity	White	90.0	84.2-93.8	80.0	73.0-85.5
	Black	0	--	9.4	5.7-15.0
	Asian	0	--	1.3	3.1-4.9
	Native American/ Alaska Native	0.6	0.1-4.4	0.6	0.1-4.4
	Hispanic	1.3	3.1-4.9	0	--
	Other	1.3	3.1-4.9	1.9	0.6-5.7
	Unspecified	6.9	3.8-12.6	6.9	3.8-12.6
Type of residence	Home (single family)	91.9	86.4-95.3	78.7	71.6-84.5
	Other or unknown	8.1	4.7-13.6	21.3	15.5-28.3
Service-connected disability (SCD)	No SCD	49.4	43.6-57.1	48.7	41.0-56.5
	Not service connected or 0-40%	15.6	10.7-22.2	13.1	8.7-19.4
	SCD rating 50-100%	35.0	27.9-42.8	38.1	30.9-46.0
Body mass index (BMI, kg/m^2)	Normal weight (<25.0)	13.7	9.2-20.1	19.4	13.9-26.3
	Overweight (25.0-29.9)	31.9	25.1-39.6	26.3	19.9-33.7
	Obese (≥30.0)	53.1	45.3-60.8	51.3	43.5-59.0
	Missing	1.3	0.3-4.9	3.1	1.3-7.3

Variable	Categories	Rural Veterans (n=160)		Urban Veterans (n=160)	
		%	95% CI	%	95% CI
Health conditions	Diabetes	56.9	49.0-64.4	60.6	52.8-68.0
	Diabetes complication	46.9	39.2-54.7	47.5	39.8-55.3
	Peripheral artery disease	50.6	42.8-58.4	43.7	36.2-51.6
	Congestive heart failure	25.6	19.4-33.0	20.6	15.0-27.7
	Coronary artery disease	42.5	35.0-50.4	31.9	25.1-39.6
	Cerebrovascular disease	15.0	10.2-21.5	18.7	13.4-25.6
	Hypertension	85.6	79.2-90.3	78.7	71.6-84.5
	Myocardial infarction	18.7	13.4-25.6	15.6	10.7-22.2
	Renal disease	25.6	19.4-33.0	20.0	14.5-27.0
	Liver disease	1.9	0.6-5.7	3.7	1.7-8.2
	Connective tissue disease	1.9	0.6-5.7	5.0	2.5-9.7
	Lower limb paralysis	2.5	0.9-6.5	8.7	0.5-14.3
	Cancer	18.7	13.4-25.6	8.1	4.7-13.6
	HIV/AIDS	0	--	0	--
LL history	Neither wound nor amputation	45.6	38.0-53.5	30.6	23.9-38.3
	Wound, without amputation	30.0	23.3-37.6	41.9	34.4-49.7
	Amputation, with or without wound	24.4	18.3-31.7	27.5	21.1-35.0
VHA primary care provider	Yes	78.1	71.0-83.9	72.5	65.0-78.9
Received Medicare-financed wound care	Yes	13.7	9.2-20.1	11.9	7.6-17.9

CI: confidence interval

VHA: Veterans Health Administration

Table 2. Lower limb wound characteristics and utilization among rural and urban Veterans.

Variable	Category	Rural Veterans (n=160)		Urban Veterans (n=160)	
WOUND CHARACTERISTICS					
Wound location %, 95% CI	First (great) toe	10.6	6.7-16.5	12.5	8.2-18.7
	2^{nd}-5^{th} toe	13.1	8.7-19.4	10.6	6.7-16.5
	Heel or plantar midfoot	21.9	16.1-29.0	25.0	18.8-32.4
	Dorsal foot	4.4	2.1-8.9	3.7	1.7-8.2
	Ankle	15.6	10.7-22.1	16.9	11.8-23.6
	Shin	12.5	8.2-18.7	10.6	6.7-16.5
	Calf	10.6	6.7-16.5	8.1	4.7-13.6
	Thigh	5.6	2.9-10.5	3.7	1.7-8.2
	Previous amputation site	5.6	2.9-10.5	8.7	5.2-14.3
Wound etiology %, 95% CI	Arterial	12.5	8.2-18.7	16.9	11.8-23.6
	Diabetic	31.3	24.5-38.9	30.0	23.3-37.6
	Neuropathic	3.1	1.3-7.3	1.9	0.6-5.7
	Venous	21.3	15.5-28.3	20.6	15.0-27.7
	Pressure	7.5	4.3-12.8	9.4	5.7-15.0
	Infectious	12.5	8.2-18.7	5.0	2.5-9.7
	Other	7.5	4.3-12.8	10.0	6.2-15.8
	Mixed[±]	4.4	2.1-8.9	6.3	3.4-11.3
Baseline wound characteristics %, 95% CI	Complex anatomy[§]	31.3	24.5-38.9	31.9	25.1-39.6
	Exposed bone, tendon, or joint or osteomyelitis	8.9	5.3-14.5	8.1	4.7-13.6
UTILIZATION CHARACTERISTICS					
Wound treatment visits Mean per person, SE	***VHA***				
	Outpatient: Non-specialist	1.3	0.1	1.5	0.1
	Outpatient: Wound specialist	4.2	0.3	6.9	0.7
	Outpatient: Non-wound specialist	0.07	0.04	0.006	0.006
	Hospital stays	0.6	0.08	0.6	0.8
	Skilled nursing stays	0.2	0.04	0.1	0.03

Variable	Category	Rural Veterans (n=160)		Urban Veterans (n=160)	
UTILIZATION CHARACTERISTICS (CONT.)					
	***Medicare* (among 22 rural and 19 urban dual users only)**				
	Outpatient: Non-specialist	2.3	1.2	3.6	2.6
	Outpatient: Wound specialist	1.1	0.5	0.9	0.3
	Outpatient: Non-wound specialist	0	--	0	--
	Hospital stays	0.4	0.1	0.7	0.3
	Skilled nursing stays	0.2	0.1	0.3	0.1

CI: confidence interval

VHA: Veterans Health Administration

§Complex anatomy includes Charcot foot, hammer toe, or previous amputation at wound site

±Mixed etiology includes any wounds that could not clearly be defined by one of the categories listed but instead had features of two different underlying conditions, such as arterial disease and diabetes

Table 3. Adjusted[±] competing risks proportional hazards regression results for wound healing among Veterans with chronic lower limb wounds.

Residence category	**Primary Outcome**		**Competing Risks**			
	Wound healed (n=234 events)		Wound amputated (n=27 events)		Veteran died with wound (n=20 events)	
	Hazard Ratio (95% CI)	p-value	Hazard Ratio (95% CI)	p-value	Hazard Ratio (95% CI)	p-value
Urban	Reference		Reference		Reference	
Rural	1.11 (0.84-1.47)	0.45	2.65 (1.02-6.87)	0.045	0.35 (0.12-0.97)	0.043

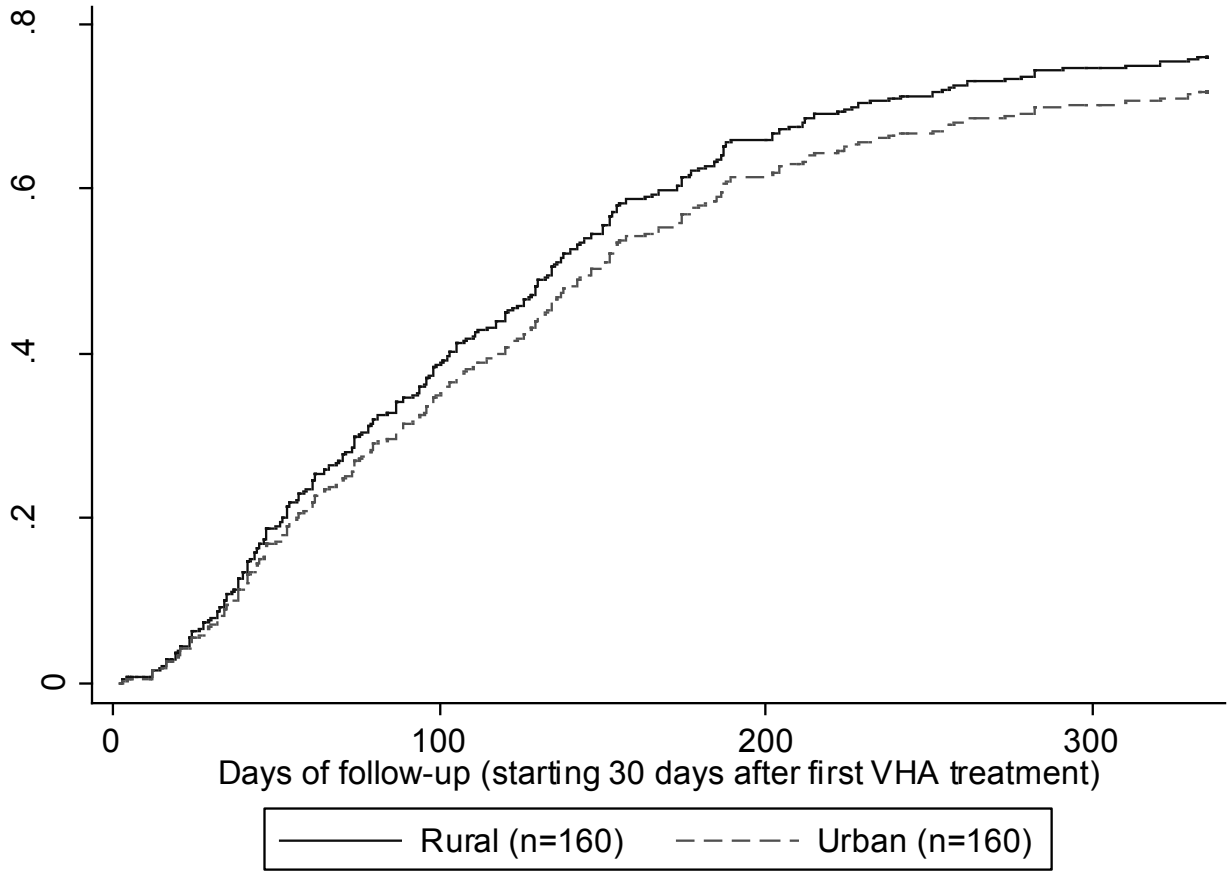
Reference: Reference category in regression model (HR=1.0)

CI: confidence interval

VHA: Veterans Health Administration

[±]Adjusted for: age (including age squared and age cubed); marital status; living at home; having a VHA primary care provider at baseline; dual VHA-Medicare wound care use; service-connected disability ≥50%; number of comorbid conditions; lower limb wound and amputation history; wound etiology; complex anatomy at wound site; and exposed bone, joint, or tendon or osteomyelitis at baseline

Figure 1. Cumulative incidence of chronic lower limb (LL) wound healing among rural and urban Veterans in VISN 20 from October 1, 2006-September 30, 2007 based on competing risks proportional hazards model[±].



[±]Adjusted for age (including age squared and age cubed), marital status, living in a single family home, having a VHA primary care provider at baseline, dual (Medicare and VHA) wound care use, service connected disability level, number of comorbid conditions, LL wound and amputation history, wound etiology, and exposed bone, tendon, or joint at baseline.

CHAPTER 3. VHA-EXCLUSIVE WOUND CARE USE IS ASSOCIATED WITH BETTER WOUND OUTCOMES THAN MEDICARE-VHA DUAL USE

Abstract

Up to half of VHA outpatient users also use Medicare. This dual system use may improve care by increasing options or it may worsen care because of fragmentation. The purpose of this study was to assess whether dual system use of VHA and Medicare was associated with wound care utilization and chronic wound healing. We conducted a retrospective cohort study of 227 Medicare-enrolled Veterans in the Pacific Northwest who had an incident chronic lower limb (LL) wound and at least one outpatient VHA visit between October 1, 2006 and September 30, 2007. All wounds were identified through the VHA medical record and followed for up to one year. We searched Medicare administrative files to identify dual system wound care during follow-up. We used Poisson models to assess whether outpatient and inpatient utilization differed for dual users and VHA-exclusive users and a proportional hazards model to compare wound healing among VHA-exclusive and dual users, treating amputation and death as competing risks. Dual (18.5% of sample) and VHA-exclusive users were similar, with some differences in wound etiology and LL wound and amputation history. Dual users had significantly higher inpatient wound care utilization than VHA-exclusive users (p=0.001). In the adjusted model, dual use was associated with a significantly lower hazard of wound healing compared to VHA-exclusive use (HR=0.38, 95%CI: 0.25-0.56, p<0.001). Mechanisms for poorer wound healing among dual users need to be explored.

Introduction

Veterans, like other US adults, are eligible for Medicare coverage at the age of 65, or earlier with a qualifying disability. About 48% of Veterans who use the Veterans Health Administration (VHA) for health care are eligible for Medicare (59); these Veterans may use the VHA for health care exclusively or in conjunction with Medicare. An estimated 10% of all Veterans (24, 60) and up to half of Veterans using outpatient VHA services (61) are Medicare-VHA dual users. Therefore, it is important to consider both VHA and Medicare systems when assessing health care utilization, health care quality, and health outcomes among Veterans (62).

In general, patients who use multiple health care systems have higher health care utilization than single system users (23, 63).This higher utilization likely is due, in part, to the higher burden of comorbidity and disability among people who are eligible for multiple systems of care (63-65). However, higher utilization could indicate better access to needed services. There is evidence that at least some Veterans use Medicare to augment their VHA care; several studies have reported that Veterans receive primary care through VHA while using non-VHA sources for specialty care (14; 66-67). In these cases, the use of multiple health care systems may improve health care outcomes by increasing treatment options (24, 64, 68).

Conversely, Hester et al. found that 41% of Veterans accessed primary care through both VHA and Medicare and none of these Veterans reduced their VHA utilization after enrolling in a Medicare HMO, indicating duplication across systems (66). This duplication has implications not only in terms of health care system costs, which are higher among dual users than VHA-exclusive users (64), but also in terms of confusion for patients and providers. Thus,

dual use may result in poorer outcomes because of poorly coordinated health care delivery (24, 64, 68).

Several studies have assessed the impact of dual system use on health outcomes. Helmer et al. found that Veterans with diabetes who used both VHA and Medicare had higher hemoglobin A1c (HbA1c) compared to VHA-exclusive users, indicating poorer glycemic control for dual users (23). Wolinsky et al. found an association between dual use of inpatient services and mortality among Medicare-VHA users compared to non-Veteran Medicare-exclusive users (hazard ratio=1.56 adjusted for sociodemographic factors, comorbidity, hospitalizations, and selection bias) (24). These findings suggest that dual use is associated with poorer health outcomes.

An estimated 6.5 million US patients experience chronic wounds annually, and these wounds cause disability and reduce quality of life (8). Most chronic wounds occur on the lower limbs (LL) of people with at least one underlying chronic health condition, most commonly diabetes, venous disease, or arterial disease (5). A coordinated treatment plan with a high level of guideline-concordant care improves the likelihood of healing and prevents amputation in patients with chronic wounds (69-71). Chronic wound outcomes are sensitive to the organization and delivery of health care and therefore present an informative case study for other health conditions and outcomes associated with dual system use.

Currently, little is known about how dual use impacts chronic wound care utilization and outcomes. The purpose of this study was to describe chronic wound care utilization among VHA-exclusive users and VHA-Medicare dual system users and to assess whether chronic wound care utilization and chronic wound healing differed among Veterans who used VHA

exclusively compared to those who used both Medicare and VHA for wound care (dual users). Based on the results of previous studies and the intensive health care management required for chronic wound healing, we hypothesized that dual use would be associated with higher wound care utilization and poorer wound healing than VHA-Medicare dual system use.

Methods

Subject selection and study design

We used data from a retrospective cohort study of chronic wound care treatment and outcomes among a random sample 320 rural and urban Veterans in the Pacific Northwest. We identified subjects based on a set of 42 ICD-9 codes for lower limb wounds (40-41; Appendix A). Veterans were eligible if they had an incident lower limb (LL) wound between October 1, 2006 and September 30, 2007 treated within VHA; a minimum wound duration of 30 days after first VHA treatment; and at least two VHA wound treatment visits during follow-up, at least one of which had to be in an outpatient setting (Appendix B). We included only the Veteran's first eligible wound.

The baseline date was the first VHA wound care treatment visit for the study wound. Subjects were followed for up to one year after their baseline date or until the wound resolved by healing, amputation, or Veteran death. We refer to the time between the baseline wound treatment visit and the resolution date as the wound episode. The VA Puget Sound Health Care System's Human Studies Subcommittee reviewed and approved this study (IRB #00253).

Medicare eligibility and dual use

We determined Medicare eligibility based on the Medicare denominator file in the calendar year of Veterans' baseline date. Medicare eligibility is based on age (≥65 years; referred to here as age-eligible), or the presence of a qualifying disability (referred to here as disability-eligible) or end-stage renal disease (ESRD; referred to here as ESRD-eligible) before age 65. We excluded Veterans whose original reason for Medicare eligibility was ESRD (n=3) because these Veterans likely had different underlying health status and wound healing trajectories than other Veterans without ESRD.

Once study wounds were identified, we searched Medicare records for wound care encounters for each subject during the wound episode. We used the same set of 42 ICD-9 codes originally used to identify potential subjects to define a wound-related encounter in Medicare. Because we were interested specifically in the influence of dual use for wound care on wound outcomes, only subjects who had at least one wound-related ICD-9 code in the Medicare files for an inpatient, outpatient, or skilled nursing encounter during their wound episode were classified as dual users. All other subjects were classified as VHA-exclusive wound care users.

Wound care visits

We defined a health care encounter as a face-to-face meeting between a Veteran and a health care provider, consistent with the VHA definition (72), to define study visits. Specifically, we included inpatient hospital, skilled nursing, and outpatient health care visits in both VHA and Medicare. We excluded ancillary visits for only tests or imaging procedures. We also excluded home health care visits from this study because Medicare frequently pays for home

health care when it is requested by a VHA provider and therefore did not feel that attributing home health visits to only one system or the other (VHA or Medicare) was appropriate.

We counted only one visit per Veteran per day for wound care even if the Veteran saw multiple providers on the same date. Within VHA, we recorded all visits during which wound care treatment was provided at a VHA facility during the wound episode. Fee-basis VHA care, in which VHA refers a patient to a non-VHA facility for treatment but the VHA pays for the treatment, was rare in this study and was not counted as VHA care. Within Medicare, we required that a claim have at least one of the 42 ICD-9-CM codes relevant to wounds described above and meet the definition of an encounter outlined above in order to qualify as a wound treatment visit.

Provider type

For each visit, we classified the type of provider as wound-related specialty (e.g., dermatology, vascular surgery), non-wound-related specialty (e.g., cardiology, oncology), or non-specialty (e.g., family medicine, internal medicine, emergency medicine). In VHA, the provider type was based on the provider who signed the medical record note. In Medicare, the provider type was based on the performing provider's specialty code, which was either available directly within the data file (i.e., in the carrier line file) or was identified based on the provider's National Provider Index (NPI) number (e.g., in the outpatient base file). We used the NPI Registry website available through CMS to look up the provider's specialty. If a Veteran saw more than one provider on the same day we recorded the most specialized provider type for the visit (i.e., wound care specialist, followed by other specialist, then non-specialist provider).

Visit type

The visit setting was classified as outpatient or inpatient. Outpatient visits included scheduled or urgent care visits. We used Evaluation and Management (E/M) codes to classify visits as scheduled (office visits or office consults: 99201-99205, 99211-99215, 99241-99245) or urgent (99281-99285). Inpatient visits included hospital- or skilled nursing facility-based stays. We considered the time from admission to discharge within a single facility to be a stay. We did not count transfers between facilities as a single stay since these transfers could have occurred between VHA and non-VHA facilities and would have then been included in both VHA and Medicare counts.

Wound healing

A wound was considered healed at the visit when a provider stated it had completely re-epithelialized or healed. Wounds had to remain closed for at least 30 days to be considered healed. If no healing was documented but the wound was on a healing trajectory (i.e., a provider stated it was closing or nearly healed), we recorded the healed date as the date of the next visit when the wound was not mentioned. If the next visit was more than 6 months after the preceding wound treatment visit, we recorded the midpoint between visits as the healed date.

Covariates

We used the VHA's electronic health record and Medicare's denominator file to collect information on covariates considered to be relevant for utilization and wound healing. From the VHA, we recorded baseline age, gender, race, ethnicity, rural residence, and health conditions

present at baseline. In descriptive tables, we report age as under 65 or 65 and older while in the analytic model we included it as a continuous variable. From Medicare, we recorded Veterans' race and ethnicity category: white, black, Asian, Native American, Hispanic, or other. We classified Veterans as living in a rural residence using the VA classification system in place at the time of the study, which relied on the residential zip code and utilized United States Census Bureau-defined Urbanized Areas. Census 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 were considered urban and all non-urban areas were classified as rural.

We used VHA physician progress notes and the "Problem List" to determine whether the Veteran had any of the following chronic health conditions or events at baseline: diabetes, peripheral artery disease, hypertension, congestive heart failure, coronary artery disease, myocardial infarction, cerebrovascular disease, renal insufficiency or renal disease, liver disease, lower limb paralysis, connective tissue disease (e.g., rheumatoid arthritis, lupus), cancer, and HIV/AIDS. In order to limit the number of covariates in our models, we created a variable that represented the number of conditions a Veteran had at baseline. We added one additional point if the Veteran had a diabetes-associated complication (sensory neuropathy, renal disease, or retinopathy), similar to the Charlson-Deyo comorbidity index (42). The maximum possible comorbidity score was 14. We created a variable to represent Veterans' lower limb history with categories for (1) a previous LL wound without amputation, (2) a previous LL amputation with or without a wound, and (3) neither a previous LL wound nor LL amputation.

We classified Veterans as having or not having an established primary care provider within VHA at baseline based on VHA chart notes. Service-connected disability (SCD) represents the average impairment in earning capacity resulting from a disease or injury related to a Veteran's military service (43). Veterans with a SCD rating of 50% or higher are eligible for free VHA care for the condition; Veterans with lower SCD ratings may be eligible for free care if they are low income (22). We categorized Veterans' SCD rating as either below 50% (including not SCD eligible) and 50-100% to reflect priority status within VHA. We used the Medicare denominator file to classify each Veteran's original reason for Medicare eligibility as either age-eligible or disability-eligible.

For each wound, we classified the etiology based on ICD-9 diagnosis codes and VHA provider chart notes, preferentially recording specialists' diagnoses in the case of conflicting assessments. Etiologic categories included arterial, diabetic, neuropathic, venous, pressure, infectious, other (including burns or trauma in people without underlying health conditions, or dermatologic conditions like pyoderma gangrenosum), and mixed. We also recorded whether complex anatomy – e.g., Charcot foot or previous amputation – was present at the wound site at baseline. Finally, as a measure of wound severity we classified whether at baseline the wound had exposed bone, tendon, or joint or evidence of osteomyelitis (bone infection).

Statistical analysis

We described the sample, including demographics, baseline health, and wound characteristics by calculating the proportions of VHA-exclusive and dual users within each category.

Utilization

To describe wound care utilization, we calculated the mean number of visits per person. We used Poisson regression with robust standard errors to model the association between dual use and wound care utilization (44), specifying a truncated distribution for outpatient visits since we required at least one of these visits for study inclusion (45). We adjusted for potential confounding factors, namely age (64), chronic conditions (63-65), rural residence (14, 17), and original reason for Medicare eligibility (73). We also adjusted for time of follow-up since Veterans with more follow-up time would have potential for more encounters. We considered squared and cubed terms for continuous variables and retained them in the model if their associated p-value was <0.05. We created two separate models, one for outpatient wound care visits and the other for inpatient wound care stays, since the scale of these two types of care differed. We assessed whether rural residence or the original reason for Medicare eligibility modified the association between dual use and utilization, using $p<0.10$ for the interaction term to indicate statistical significance.

Wound healing

We used competing risks proportional hazards models to calculate the estimated hazard ratio (HR) of wound healing, accounting for the competing risks of amputation or death, and censoring people lost to follow-up (46). We used a competing risks approach because people who undergo amputation to resolve their wound or who die with an active wound are likely to have had more severe wounds and/or underlying disease that result in the poorer outcome (49-50); therefore, standard approaches to estimating hazard ratios (e.g., Cox proportional hazards model) would be inappropriate since they assume that censoring is independent of the time to

event. We compared dual users to Medicare-eligible VHA exclusive users. An HR>1 indicates a higher rate of healing among dual users compared to VHA-exclusive users while an HR<1 indicates a lower rate of healing among dual compared to VHA-exclusive users.

We adjusted for the following potential confounders based on existing literature: age (49, 64), chronic conditions (30, 49-50), having a VHA primary care provider at baseline (66), rural residence (17, 64), SCD ≥50% (64), lower limb history (30, 49), complex anatomy at wound site (49), and wound severity (49). We assessed whether the original reason for Medicare eligibility acted as an effect modifier based on previous literature suggesting differences in utilization for disability-eligible compared to age-eligible Veterans (73). We considered a p-value<0.10 (*a priori*) to indicate a significant interaction between eligibility and dual use. We tested whether proportional hazards assumptions for the model were satisfied using Schoenfeld residual plots, and we used delta beta plots to identify influential subjects (47). We plotted cumulative incidence curves to display overall time to healing for dual users and VHA-exclusive users, adjusted for covariates (46, 52). All analyses were conducted in STATA 12.1 (College Station, TX).

Sensitivity analyses

We conducted three different sensitivity analyses for the association between dual use and wound healing. First, during the study period, the Walla Walla VAMC was participating in an intervention designed to improve wound care (40-41) and therefore may have provided different wound care than other sites. This sensitivity analysis excluded Veterans who received

care at the Walla Walla VAMC to determine whether this concurrent intervention impacted our study.

Second, using the VHA record to establish the resolution dates for all wounds might result in bias among dual users. For example, a Veteran who used Medicare coverage for wound care may have been seen less frequently within the VHA as a result so we could have overestimated the time to healing for dual users by using only VHA information to determine the resolution date. In this sensitivity analysis we re-assigned wound resolution dates for dual users based on the Medicare data; specifically, we recorded the date of the last visit on which a wound-related ICD code appeared, if earlier than the VHA resolution dates and if not followed by VHA visits that clearly demonstrated the wound was not resolved.

Finally, we conducted a sensitivity analysis excluding Veterans who were enrolled in a Medicare HMO at any point during their wound episode. Visits paid for by a Medicare HMO are not available in the administrative Medicare files, which include only fee-for-service records. As a result, we might have misclassified Veterans who used Medicare HMO-financed wound care as VHA-exclusive users in this study.

Results

Veteran and wound characteristics

The average age of both dual users and Medicare-eligible VHA-exclusive users at baseline was 69 years. The demographic characteristics of both groups of Veterans were similar (Table 4). The mean number of chronic health conditions was 4.1 (SD=2.3) for both dual users and VHA-exclusive users. The prevalence of diabetes at baseline was around 60% and the

prevalence of peripheral artery disease was about 53%. Nearly half of dual users and about one in three VHA-exclusive users had had a previous LL wound that healed and 19% of dual users and 27% of VHA-exclusive users had had a previous LL amputation. Wound etiology varied somewhat, with dual users more frequently having arterial wounds and VHA-exclusive users more frequently having diabetic and venous wounds.

Wound care utilization

Dual users and VHA-exclusive users had similar numbers of mean visits per person in each category of visit type within VHA; however, given the additional utilization within Medicare, dual users tended to have higher utilization overall (Figure 2). Wound-related outpatient specialty care was the most frequently utilized; around 90% of Veterans (93% of dual users and 88% of VHA-exclusive users) had at least one wound-related specialty visit. Dual users had higher utilization of wound-related specialty care within VHA (mean 5.8 visits) than in Medicare (mean 1.0 visits). Across systems, 58% of dual users and 38% of VHA-exclusive users had at least one wound-related inpatient stay and 29% and 8%, respectively, had a skilled nursing facility stay. The mean number of stays was 1.7 for dual users and 0.7 for VHA-exclusive users.

In an unadjusted truncated Poisson model, dual users had significantly higher outpatient ($p<0.001$) and inpatient ($p<0.001$) wound care utilization than VHA-exclusive users. We found no evidence of an interaction between rural residence and dual use for either outpatient or inpatient utilization ($p=0.49$ and $p=0.76$ for interaction, respectively). Likewise, we did not find evidence of an interaction between the original reason for Medicare eligibility and dual use

(p=0.89 for interaction in outpatient model and p=0.69 in inpatient model). Therefore, we included rural residence and the original reason for Medicare eligibility as covariates in both models, along with age, age squared, the number of comorbid conditions, follow-up time, SCD rating ≥50%, and baseline wound severity. In the adjusted model, we found dual users' outpatient wound care utilization was no longer statistically significantly different than VHA-exclusive users' outpatient utilization (p=0.093), but inpatient utilization did differ significantly after adjustment (p=0.001). When the covariates were set at their means, the predicted number of outpatient visits among dual users was 8.5 (95% CI: 6.7-10.2) while among VHA-exclusive users it was 6.9 (95% CI: 6.2-7.7). For inpatient stays, the predicted counts were 1.4 (95% CI: 0.8-2.0) for dual users and 0.6 (95% CI: 0.5-0.8) for VHA-exclusive users. For both the outpatient and inpatient models, there was evidence that the models did not fit the data well based on plots of the observed and predicted values, residuals, and a deviance goodness-of-fit chi-square test.

Wound outcomes

During one year of follow up, 165 Veterans experienced wound healing (20 dual users and 145 VHA-exclusive users), 17 underwent amputation (6 dual users and 11 VHA-exclusive users), 17 died with active wounds (6 dual users and 11 VHA-exclusive users), and 28 were unresolved at one year (9 dual users and 19 VHA-exclusive users). In the unadjusted competing risks proportional hazards model, dual use was associated with a statistically significantly lower hazard of wound healing (HR=0.39, 95%CI: 0.25-0.59, p<0.001). We did not find any interaction between the original reason for a Veteran's eligibility for Medicare (age versus disability) and

dual use (p for interaction=0.32 in adjusted model); therefore, we present the results for the full sample here rather than results stratified by eligibility. After adjusting for age, rural residence, having a VHA primary care provider, SCD rating ≥50%, the original reason for Medicare eligibility, number of comorbid conditions, lower limb wound/amputation history, complex wound site anatomy, and baseline wound severity, the significantly poorer wound healing for dual users compared to VHA-exclusive users remained (HR=0.38, 95%CI: 0.25-0.56, p<0.001; Table 5). Figure 3 illustrates the higher cumulative incidence of wound healing among VHA-exclusive users compared to dual users. The median time to healing from the baseline visit was 205 (95%CI: 173-230) days for dual users and 117 (95%CI: 104-129) days for VHA-exclusive users.

In the competing risks models, dual users were significantly more likely than VHA-exclusive users to undergo amputation (adjusted HR=3.73, 95% CI: 1.10-12.63, p=0.034) Median time to amputation was 149 (95%CI: 36-319) days after baseline among dual users and 91 (95%CI: 39-272) days after baseline among VHA-exclusive users. Most amputations (67%) were toe or transmetatarsal level among dual users, compared to 27% among VHA-exclusive users. Dual users also were more likely to die with an active wound (adjusted HR=3.89, 95%CI: 1.23-12.28, p=0.020). The median time to death was 154 (95%CI: 57-179) days after baseline among dual users and 95 (95%CI: 71-225) days among VHA-exclusive users.

Sensitivity analyses

When we excluded Veterans who received care at the Walla Walla VHA (n=17; 10 VHA-exclusive and 7 dual users), the results were similar but attenuated somewhat compared to the

main analysis for wound healing (HR=0.41, 95%CI: 0.27-0.61, p<0.001) and death (HR=3.50, 95%CI: 1.12-10.93, p=0.031). There was no significant difference in amputation (HR=1.41, 95% CI: 0.27-7.39, p=0.69) in this sensitivity analysis. There were 14 dual users who had an earlier wound resolution date based on the Medicare record; differences ranged from 1 to 133 days. When we used these revised times to resolution, we found a slightly attenuated hazard ratio for wound healing (0.40, 95%CI: 0.26-0.60, p<0.001) but nearly identical hazard ratios for amputation (3.74, 95%CI: 1.11-12.66, p=0.034) and death (3.89, 95% CI: 1.23-12.26, p=0.021) compared to the main analysis. When we restricted the analysis to only Veterans who did not have any HMO enrollment during their wound episode (n=203; 23 VHA-exclusive users and 1 dual user excluded), the HR for wound healing within one year in the adjusted model moved slightly farther away from the null to 0.34 (95%CI: 0.22-0.51, p<0.001), as did the estimates for amputation (HR=4.09, 95% CI: 1.22-13.72, p=0.023) and death (HR=4.74, 95% CI: 1.35-16.61, p=0.015).

Discussion

In this first study of chronic wound outcomes among dual users, VHA-exclusive wound care use was associated with lower wound care utilization and significantly better wound healing compared to VHA-Medicare dual use. This association was robust to adjustment for multiple Veteran health, health care, and wound characteristics and also to several sensitivity analyses for all outcomes except outpatient utilization, which was no longer significantly different after accounting for Veteran health and wound variables. We used a measure of dual use specific to wound care to isolate the effect of dual system utilization on wound healing and

we restricted our regression analyses to only Medicare-eligible Veterans. These findings are consistent with other studies that have compared utilization and health outcomes among dual and single system users, though it is the first to explore chronic wound care.

In our study population, which included mostly older men, Medicare eligibility was high but dual use was low compared to other studies. The explanation for this is that we looked specifically at dual wound care use rather than dual use for any reason. Dual users had higher observed utilization within both systems of care than VHA-exclusive users. It is not clear from these data whether there are some characteristics of dual users that make them high utilizers, or if the high utilization is an inherent result of using multiple systems of care. Understanding this distinction is important and may explain why we were unable to develop utilization models that fit the data well; we likely were lacking covariate measures needed to fully describe the association between dual use and utilization. Although others have noted that dual users generally have more chronic and other health conditions than single-system users (64-65, 74), in this study we compared dual users to Medicare-eligible VHA-exclusive users, who had a similarly high comorbidity burden, and we included comorbidity in our regression model. Therefore, it is unlikely that our finding of higher utilization among dual users is the result of unmeasured confounding by health status. However, residual confounding by factors not measured in this study is possible, so additional research is needed to replicate our findings and identify other potential explanations for the observed associations.

There are several limitations to this study, some of which we were able to address or minimize. The first relates to differences between data sources across VHA and Medicare. As described by Burgess et al., the purpose of an administrative dataset influences the information

contained in that dataset and its utility in research (75). In this study, we used chart notes intended for patient care purposes for one health system (VHA) and administrative data intended for payment and reimbursement purposes in the other health system (Medicare). The payment-based Medicare data were insufficient to allow us to compare the specifics of care delivered by Medicare-reimbursed providers and to be certain whether ICD codes related to a study wound or a subsequent wound, for example. We therefore relied primarily on VHA data and conducted sensitivity analyses to assess whether this decision created bias by extending the wound resolution date for dual users compared to VHA-exclusive users. The results of the sensitivity analyses suggest that these differences did not result in substantial bias. The lack of specificity of wound-related ICD-9 codes makes it challenging to ascertain wound care using administrative data alone. Without having detailed chart notes that describe the location of the wound, it would have been impossible to be certain that a given code related to the same wound. ICD-10 codes, which include location modifiers (e.g., S91.301 is an unspecified open wound, right foot), may somewhat ameliorate this problem when implemented.

Another limitation of the study is its use of only fee-for-service Medicare and VHA wound care; we did not include wound care paid for through private insurance (including Medicare HMOs), Medicaid, or Indian Health Service. Omitting these other sources of care may have underrepresented the extent of wound care or the complexity across systems in our analyses (68, 76), which in turn could have biased our results. Based on the VHA medical record, 32% of dual users and 24% of VHA-exclusive users had private insurance coverage at the time of their wound. In a sensitivity analysis, we excluded Veterans who were enrolled in a Medicare HMO at any point during their wound episode. In general, an estimated 15% of

Veterans enrolled in Medicare have an HMO and these enrollees tend to be healthier than other Medicare enrollees (74), so it is somewhat surprising that excluding them moved our point estimate away from the null given that nearly all HMO enrollees were VHA-exclusive users. Perhaps a more accurate explanation for our sensitivity analysis is that the Veterans enrolled in a Medicare HMO were misclassified as VHA-exclusive users when, in truth, they were dual users so their inclusion made the VHA-exclusive users look worse than they truly were.

The interpretation of these findings is limited somewhat by the small number of dual wound care users and the resulting imprecision in estimates related to amputation and death. The confidence intervals for these estimates were wide and additional work is needed to replicate our findings and to establish more precise estimates.

Finally, this sample was limited to Veterans who used VHA for at least one follow-up wound care visit. Therefore, these results are not representative of Veterans who use VHA with very low frequency or those who receive all of their wound care outside of VHA. Veterans with higher VA priority ratings (i.e., those who are eligible for free or reduced-cost care) rely more heavily on VHA care (64). These Veterans may differ from other Veterans in terms of health status and income level. Although we would not expect these demographic differences to modify the association between dual use and wound healing, additional research is needed to understand utilization and outcomes across the full population of Veterans.

In spite of these limitations, the use of the medical record to identify and follow wounds made it possible to accurately identify wound onset and end dates. We also used a set of wound-related ICD codes to identify wound care visits within Medicare, making the dual use

exposure specific to our outcome of interest (wound healing). We focused on a health condition – chronic wounds – that is a prevalent problem among the population of Veterans with multiple health conditions and is sensitive to well-organized, evidence-based care.

In structuring a higher quality health care system, the Institute of Medicine committee on health care quality recommended that care be consistent across providers and regions and that clinicians cooperate with one another to provide coordinated care (77). We conceptualized dual system use involving multiple health care providers and systems, inherently introducing fragmentation into healthcare, and reducing consistency and coordination. This view is supported by a recent survey of 1,006 rural Nebraska Veterans in which Nayar and colleagues found that 31% said their VHA and non-VHA providers never communicated and 15% were not sure about communication between providers (78). Furthermore, 26% of the Veterans said their VHA and non-VHA sometimes, usually, or always gave them conflicting advice and 34% said their providers agreed about healthcare needs only sometimes, rarely, or never.

Coordinated wound care has been shown to improve wound outcomes. For example, Driver and colleagues demonstrated great success in preventing lower limb amputations in a military medical center through a coordinated clinic program that includes wound care management, regular follow-up, and both patient and provider education (69). Weck et al. implemented a structured, evidence-based program of multidisciplinary care for patients with diabetic foot wounds across a region of Germany and observed significant reductions in amputation and mortality rates compared to control patients (71). It is not clear whether such a cross-facility program could be successful in the US, where different payers and health information systems are involved. The VA's Lifetime Electronic Record program, which

facilitates the sharing of Veterans' medical records across VHA and non-VHA providers, has the potential to address some of the problems with care coordination for dual users (79). Nonetheless, additional research is needed to understand why dual use results in poorer health outcomes and to identify patient and system-level factors not measured in this study – such as patient adherence, provider communication, quality of care, and cross-system coordination – that may explain some of the observed difference in wound healing for dual users.

Conclusion

A large and increasing proportion of Veterans who receive care at VHA also use other health care systems, including Medicare, so understanding how the use of multiple health care systems influences health outcomes is important. Using chronic LL wounds as a model, we found that dual system wound care users had poorer outcomes than VHA-exclusive users. As the population continues to age and more adults, including Veterans, become eligible for Medicare, dual health care system utilization is likely to continue. Additional research, including both qualitative and quantitative approaches, is needed to replicate these findings and to clearly define the mechanisms underlying the association.

Table 4. Baseline demographic, health, and wound characteristics of Veterans with chronic lower limb (LL) wounds by Medicare-VHA dual wound care use.

Variable	Category	Medicare-VHA dual users (n=41)		VHA-exclusive users (n=186)	
		%	95% CI	%	95% CI
Age (years)	<65	36.6	22.9-52.8	32.8	26.4-39.9
	≥65	63.4	47.2-77.1	67.2	60.1-73.6
Gender	Male	95.1	81.6-98.9	98.9	95.7-99.7
Race/ ethnicity	White	92.7	78.8-97.7	91.9	87.0-95.1
	Black	7.3	2.3-21.2	3.8	1.8-7.7
	Asian	0	--	1.1	0.3-4.2
	Native American/ Alaska Native	0	--	0.5	0.1-3.8
	Hispanic	0	--	0.5	0.1-3.8
	Other	0	--	2.1	0.8-5.6
Rural residence	Yes	53.7	37.9-68.7	53.2	46.0-60.3
Service-connected disability (SCD)	Not service connected or 0-40%	65.9	49.6-79.1	34.1	20.9-50.4
	SCD rating 50-100%	67.2	60.7-73.6	32.8	26.4-39.9
VHA primary care provider	Yes	82.9	67.5-91.9	72.6	65.7-78.6
Original reason for Medicare eligibility	Age ≥65	39.0	24.9-55.2	49.5	42.3-56.7
	Disability before age 65	61.0	44.8-75.1	50.5	43.3-57.7
Health conditions	Diabetes	61.0	44.8-75.1	58.1	50.8-65.0
	Diabetes complication	43.9	29.1-59.8	49.5	42.3-56.7
	Peripheral artery disease	53.7	37.9-68.7	53.2	46.0-60.3
	Congestive heart failure	21.9	11.5-37.8	28.5	22.4-35.5
	Coronary artery disease	46.3	31.3-62.1	41.9	35.0-49.2
	Cerebrovascular disease	19.5	9.8-35.2	21.5	16.1-28.1

Variable	Category	Medicare-VHA dual users (n=41)		VHA-exclusive users (n=186)	
		%	95% CI	%	95% CI
Health conditions (continued)	Hypertension	78.0	62.2-88.5	84.4	78.4-89.0
	Myocardial infarction	26.8	15.1-43.0	16.1	11.5-22.2
	Renal disease	19.5	9.8-35.2	29.0	22.9-36.0
	Liver disease	0	--	3.2	1.4-7.0
	Connective tissue disease	4.9	1.1-18.4	4.3	2.1-8.4
	Lower limb paralysis	14.6	6.5-29.7	5.9	3.3-10.4
	Cancer	17.1	8.1-32.5	14.5	10.1-20.4
	HIV/AIDS	0	--	0	--
LL history	Neither wound nor amputation	34.1	20.9-50.4	38.7	31.9-46.0
	Wound, without amputation	46.3	31.3-62.1	34.4	27.9-41.6
	Amputation, with or without wound	19.5	9.8-35.2	26.9	20.9-33.8
Wound etiology	Arterial	29.3	17.0-45.5	16.1	11.5-22.2
	Diabetic	21.9	11.5-37.8	29.6	23.4-36.6
	Neuropathic	4.9	1.1-18.4	2.7	1.1-6.3
	Venous	14.6	6.5-29.7	24.2	18.5-30.9
	Pressure	14.6	6.5-29.7	9.1	5.7-14.3
	Infectious	4.9	1.1-18.4	8.1	4.9-13.0
	Other	4.9	1.1-18.4	7.0	4.1-11.7
	Mixed[±]	4.9	1.1-18.4	3.2	1.4-7.0
Baseline wound characteristics	Complex anatomy at wound site§	21.9	11.5-37.8	32.8	26.4-39.9
	Exposed bone, tendon, or joint or osteomyelitis	9.7	3.5-24.1	8.1	4.9-13.0

CI: confidence interval

VHA: Veterans Health Administration

§Complex anatomy includes Charcot foot, hammer toe, or previous amputation at wound site

±Mixed etiology includes any wounds that could not clearly be defined by one of the categories listed but instead had features of two different underlying conditions, such as arterial disease and diabetes.

Figure 2. VHA and Medicare wound care utilization by visit type and system of care among dual and VHA-exclusive wound care users.

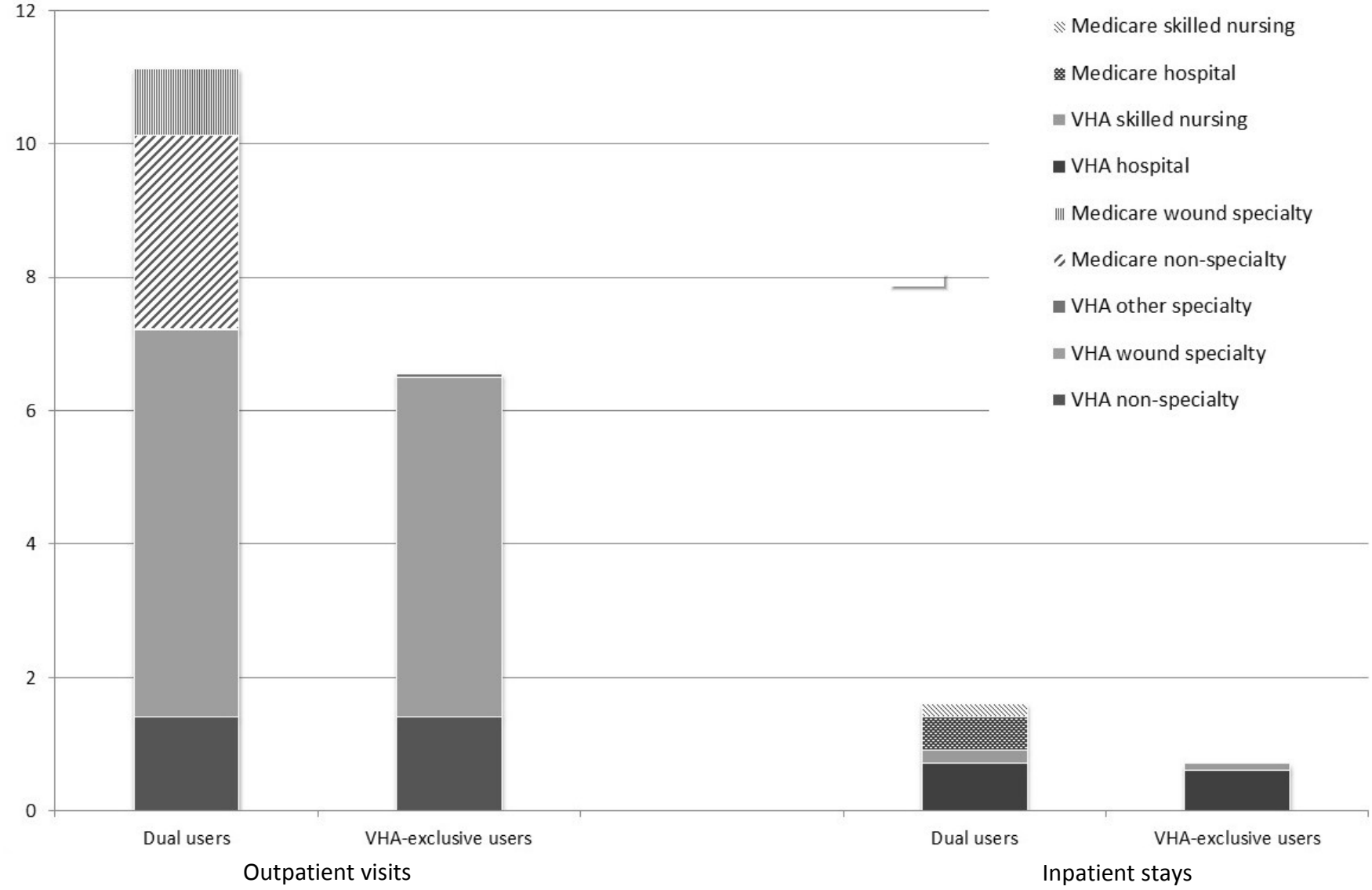


Table 5. Adjusted[±] competing risks proportional hazards regression results for wound healing among Veterans with chronic lower limb (LL) wounds.

Dual wound care use	**Primary Outcome**		**Competing Risks**			
	Wound healed (n=165 events)		Wound amputated (n=17 events)		Veteran died with wound (n=17 events)	
	Hazard Ratio (95% CI)	p-value	Hazard Ratio (95% CI)	p-value	Hazard Ratio (95% CI)	p-value
VHA-exclusive (n=186 Veterans)	Reference		Reference		Reference	
Dual use VHA (n=41 Veterans)	0.38 (0.25-0.56)	<0.001	3.73 (1.10-12.63)	0.034	3.89 (1.23-12.28)	0.020

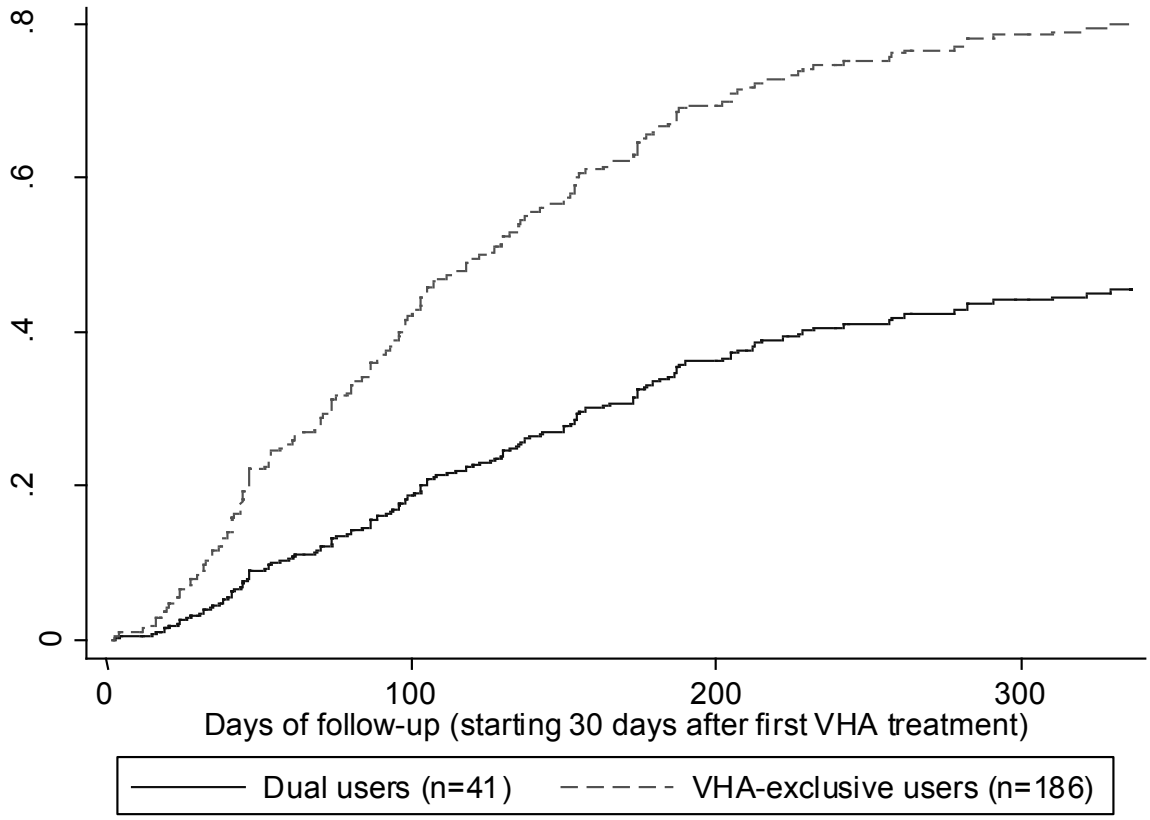
Reference: Reference category in regression model (HR=1.0)

CI: confidence interval

VHA: Veterans Health Administration

[±]Adjusted for: age centered at 65, having a VHA primary care provider at baseline, rural residence, SCD category, comorbid conditions, lower limb history, complex anatomy at wound site, and wound severity (exposed bone, joint, or tendon at any time during follow-up)

Figure 3. Cumulative incidence of chronic lower limb wound healing among rural and urban Veterans in VISN 20 from October 1, 2006-September 30, 2007 based on competing risks proportional hazards model[±].



[±]Adjusted for: age, having a VHA primary care provider at baseline, rural residence, service-connected disability rating category, number of comorbid conditions, lower limb wound and amputation history, complex anatomy at wound site, and wound severity (exposed bone, joint, or tendon at any time during follow-up)

CHAPTER 4. CONCLUSION

VHA's efforts to improve the accessibility of healthcare facilities in rural areas have been successful in increasing the options for health care available to rural Veterans, although some barriers remain (17, 80-81). In the current study, rural Veterans had lower wound care utilization than urban Veterans, but the reasons for this difference are not clear from our data alone. A recent interview-based study by Nayar and colleagues found that rural Veterans who use the VHA system along with at least one other health care system (dual users) report doing so primarily because of established relationships with providers outside VHA (45%) and because of long distances to their nearest VHA facility (35%) (78). Veteran satisfaction with the care and the timeliness of appointments within VHA were high.

Rural and urban Veterans had similar hazards of wound healing, but dual users were at a significant disadvantage compared to VHA-exclusive users when it came to wound healing. In the study by Nayar et al., 31% said their VHA and non-VHA providers never communicated and 48% said they (the patients) acted as the communicator between providers (78). Additionally, 26% said they sometimes, usually, or always received conflicting advice from providers across systems. This poor communication may contribute to poor wound outcomes among dual users.

In a mixed methods study of rural VHA patients and providers in the Midwest conducted by Buzza and colleagues, patient and social factors like health and functional status, ability to drive, costs, and social support emerged as factors that determine the extent to which distance was a problem in accessing care (15). Patients and providers both reported that going to the VAMC for specialty care was problematic, but for care perceived to be important it was seen as part of their way of life. For emergency care and care that was perceived as more mundane,

like vision and hearing testing, Veterans were more frustrated about the distance they had to travel to receive care. These results may be helpful in future VHA planning activities around wound care. Although it is not clear where chronic wound care falls on the spectrum of health problem importance, rural Veterans may seek wound care at a distant VHA facility or may instead utilize more local wound care through Medicare. If single-system use is better for Veterans, the VHA may need to consider patient and social factors in designing programs or policies that support exclusive VHA utilization for chronic wound care.

The VHA offers Veterans an integrated health care system with an electronic health record accessible to all providers in the system. Veterans who choose to receive care outside of VHA sacrifice the integration of their care, potentially with negative health consequences. These dissertation studies suggest that Veterans with chronic LL wounds who use VHA and Medicare experience poorer wound healing, but the mechanism for this association is not clear. We did not measure coordination or continuity and future research in this area would be helpful to understanding why dual use is associated with poorer outcomes. We also did not include any patient-reported information in this study, which could illuminate decision-making processes and reasons for using multiple health care systems. Patient preferences also could be useful in understanding whether the higher hazard rate for amputation (compared to death) observed in the study of rural Veterans is concerning for Veterans or not. Additional research is needed to understand potential mechanisms to explain the association between dual use and poorer wound healing and to identify interventions to improve wound outcomes for dual users.

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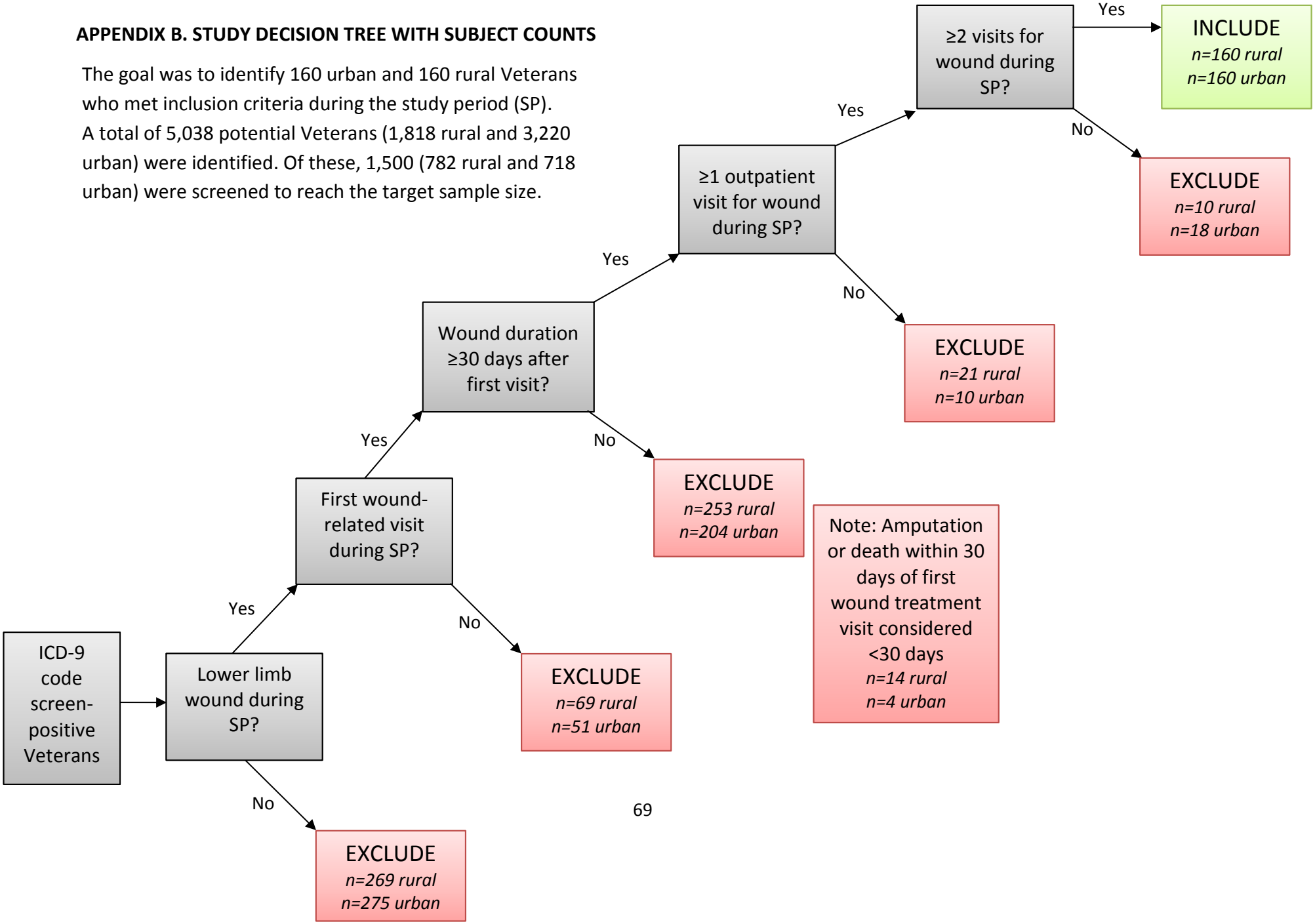
APPENDIX A. 42 WOUND-RELATED ICD-9 DIAGNOSIS CODES

ICD-9-CM code	Description
440.23	Atherosclerosis of native arteries of the extremities with ulceration
440.24	Atherosclerosis of native arteries of the extremities with gangrene
454.0	Varicose veins of lower extremities with ulcer
454.2	Varicose veins of lower extremities with ulcer and inflammation
459.31	Chronic venous hypertension with ulcer
459.33	Chronic venous hypertension with ulcer and inflammation
681.1	Cellulitis and abscess of toe
681.10	Cellulitis and abscess of toe, unspecified
681.9	Cellulitis and abscess of unspecified digit
682.6	Cellulitis and abscess of leg, except foot
682.7	Cellulitis and abscess of foot, except toes
707.06	Pressure ulcer, ankle
707.07	Pressure ulcer, heel
707.1	Ulcer of lower limbs, except decubitus ulcer
707.10	Ulcer of lower limb, unspecified
707.12	Ulcer of calf
707.13	Ulcer of ankle
707.14	Ulcer of heel and midfoot
707.15	Ulcer of other part of foot
707.19	Ulcer of other part of lower limb
707.8	Chronic ulcer of other specified sites
707.9	Chronic ulcer of unspecified site
785.4	Gangrene
891.0	Open wound of knee, leg [except thigh], and ankle, without mention of complication
891.1	Open wound of knee, leg [except thigh], and ankle, complicated
891.2	Open wound of knee, leg [except thigh], and ankle, with tendon involvement
892.0	Open wound of foot except toe(s) alone, without mention of complication
892.1	Open wound of foot except toe(s) alone, complicated
892.3	Open wound of foot except toe(s) alone, with tendon involvement
893.0	Open wound of toe(s), without mention of complication
893.1	Open wound of toe(s), complicated
893.2	Open wound of toe(s), with tendon involvement
894.0	Multiple and unspecified open wound of lower limb, without mention of complication
894.1	Multiple and unspecified open wound of lower limb, complicated
894.2	Multiple and unspecified open wound of lower limb, with tendon involvement
945.0	Burn of lower limb(s) unspecified degree
945.01	Burn of unspecified degree of toe(s) (nail)
945.02	Burn of unspecified degree of foot
945.03	Burn of unspecified degree of ankle
945.04	Burn of unspecified degree of lower leg
945.05	Burn of unspecified degree of knee
949.0	Burn of unspecified site, unspecified degree

APPENDIX B. STUDY DECISION TREE WITH SUBJECT COUNTS

The goal was to identify 160 urban and 160 rural Veterans who met inclusion criteria during the study period (SP). A total of 5,038 potential Veterans (1,818 rural and 3,220 urban) were identified. Of these, 1,500 (782 rural and 718 urban) were screened to reach the target sample size.



VITA

Erin DeFries Bouldin was born in Orlando, Florida. She earned cum laude bachelor's degrees in food science & human nutrition and zoology in 2003 and a master's degree in public health with a concentration in epidemiology in 2006 from the University of Florida. She worked as a research manager and lecturer in the Department of Epidemiology at the University of Florida under the direction of Elena Andresen through 2010, when she joined Gayle Reiber's research group at the Department of Veteran's Affairs Health Services Research & Development Center in Seattle. She completed her PhD in epidemiology at the University of Washington in 2014.