



## Medicare-VHA Dual Use Is Associated With Poorer Chronic Wound Healing

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### Abstract

Veterans who use Veterans Health Affairs (VHA) have the option of enrolling in and obtaining care from other non-VA sources. Dual system use may improve care by increasing options or it may result in poorer outcomes because of fragmented care. Our objective was to assess whether dual system use of VHA and Medicare for wound care was associated with poorer chronic wound healing. We conducted a retrospective cohort study of 227 Medicare-enrolled VHA users in the Pacific Northwest who had an incident, chronic lower limb wound between October 1, 2006 and September 30, 2007 identified through VHA chart review. All wounds were followed until resolution or for up to one year. Dual system wound care was identified through Medicare claims during follow-up. We used a proportional hazards model to compare wound healing among VHA-exclusive and dual wound care users, using a time-varying measure of dual use and treating amputation and death as competing risks. 18.1% of subjects were classified as dual wound care users during follow-up. After adjustment using propensity scores, dual use was associated with a significantly lower hazard of wound healing compared to VHA-exclusive use (HR=0.63, 95%CI: 0.39-0.99, p=0.047). Hazards for the competing risks, amputation (HR=4.23, 95% CI: 1.61-11.15, p=0.003) and death (HR=3.08, 95%CI: 1.11-8.56, p=0.031), were significantly higher for dual users compared to VHA-exclusive users. Results were similar in inverse probability of treatment weighted analyses and in sensitivity analyses that excluded veterans enrolled in a Medicare managed care plan and that used a revised wound resolution date based on Medicare claims data, but were not always statistically significant. Overall, dual wound care use was associated with substantially poorer wound healing compared to VHA-exclusive wound care use. VHA may need to design programs or policies that support and improve care coordination for veterans needing chronic wound care.

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## **Medicare-VHA dual use is associated with poorer chronic wound healing**

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## **Abstract**

Veterans who use Veterans Health Affairs (VHA) have the option of enrolling in and obtaining care from other non-VA sources. Dual system use may improve care by increasing options or it may result in poorer outcomes because of fragmented care. Our objective was to assess whether dual system use of VHA and Medicare for wound care was associated with chronic wound healing. We conducted a retrospective cohort study of 227 Medicare-enrolled VHA users in the Pacific Northwest who had an incident, chronic lower limb wound between October 1, 2006 and September 30, 2007 identified through VHA chart review. All wounds were followed until resolution or for up to one year. Dual system wound care was identified through Medicare claims during follow-up. We used a proportional hazards model to compare wound healing among VHA-exclusive and dual wound care users, using a time-varying measure of dual use and treating amputation and death as competing risks. 18.1% of subjects were classified as dual wound care users during follow-up. After adjustment using propensity scores, dual use was associated with a significantly lower hazard of wound healing compared to VHA-exclusive use (HR=0.63, 95%CI: 0.39-0.99, p=0.047). Hazards for the competing risks, amputation (HR=4.23, 95% CI: 1.61-11.15, p=0.003) and death (HR=3.08, 95%CI: 1.11-8.56, p=0.031), were significantly higher for dual users compared to VHA-exclusive users. Results were similar in inverse probability of treatment weighted analyses and in sensitivity analyses that excluded veterans enrolled in a Medicare managed care plan and that used a revised wound resolution date based on Medicare claims data, but were not always statistically significant. Overall, dual wound care use was associated with substantially poorer wound healing compared to VHA-exclusive wound

care use. VHA may need to design programs or policies that support and improve care coordination for veterans needing chronic wound care.

Short running title: Dual system use and chronic wounds

Key words: chronic ulcers, wound healing, dual use, veterans

## Introduction

The Veterans Health Administration (VHA) is the largest integrated health system in the United States; in 2013, 8.9 million veterans were enrolled [1]. Among these VHA enrollees, 48% were dually enrolled in Medicare, including over 90% of VHA enrollees age 65 or older. An estimated 10% of all VHA enrollees [2,3] and up to half of Medicare-eligible veterans using outpatient VHA services [4] are dual Medicare-VHA 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 [5,6].

Prior research shows that some veterans use Medicare to augment their VHA care [7,8]. For some veterans, dual use of VHA and Medicare may improve health care outcomes by increasing treatment options. However, dual Medicare-VHA use is associated with service duplication, higher costs, and poorer outcomes [2,6,9,10]. Thus, dual use may result in poorer outcomes potentially due to lack of coordination of health care delivery [2,6,11].

An estimated 6.5 million US patients experience chronic wounds annually, and these wounds cause disability and reduce quality of life [12]. Chronic wounds typically occur on the lower limbs (LL) of people with at least one underlying chronic health condition, most commonly diabetes, venous disease, or arterial disease [13]. A coordinated treatment plan with a high level of guideline-concordant care improves the likelihood of wound healing and reduces the risk of amputation [14–16]. Given that the organization and delivery of health care influences chronic wound outcomes, these wounds present an informative case study for other health conditions and outcomes associated with dual system use.

The purpose of this study was to assess whether chronic wound healing differed between dual wound care users and VHA-exclusive wound care users among Medicare-enrolled veterans. We conceptualized dual health system use as veterans seeking chronic wound care from multiple health care providers and systems. Based on previous studies and the intensive health care management required for chronic wound healing, we hypothesized that dual use would be associated with poorer wound healing than VHA-exclusive use due to a reduction in consistency and coordination of care. Currently, little is known about how dual health system use impacts chronic wound care outcomes. Understanding whether greater fragmentation of wound care introduced through dual use will help inform appropriate follow-up care for veterans with chronic wounds.

## **Methods**

### *Subject selection, study design, and data sources*

We included 227 veterans dually-enrolled in VHA and Medicare from a previous study of chronic wounds among rural and urban veterans in the Pacific Northwest. We identified potential subjects based on a set of 42 ICD-9 codes for LL wounds [17,18] then reviewed VHA chart notes to identify eligible subjects. Veterans were eligible for the study if they had an incident LL wound between October 1, 2006 and September 30, 2007 treated within VHA; a minimum wound duration of 30 days after first VHA treatment [19]; and at least two VHA wound treatment encounters, at least one of which was in an outpatient setting. The requirement of at least two encounters allowed us to track the wound outcome. The requirement of at least one outpatient visit was to limit our sample to veterans who were

healthy enough that wound healing was a reasonable expectation. We included each veteran's first eligible wound.

Baseline was the date of the first VHA wound care treatment encounter based on chart notes. Subjects were followed for up to one year after baseline or until the wound resolved. We used electronic medical record (chart) data from VHA to identify wounds and assess VHA treatment and wound outcomes. We used fee-for service claims to identify wound care in Medicare; chart notes were not available for Medicare-financed visits. The VA Puget Sound Health Care System's Human Studies Subcommittee reviewed and approved this study (IRB #00253).

#### *Medicare eligibility*

We determined Medicare eligibility based on the Medicare denominator file in the calendar year of veterans' baseline visits. We classified veterans as age-eligible ( $\geq 65$  years) or disability-eligible (qualifying disability before age 65). We excluded veterans whose original reason for Medicare eligibility was end-stage renal disease (ESRD;  $n=3$ ) because they likely had different underlying health status and wound healing trajectories than veterans without ESRD.

#### *Dual VHA-Medicare use*

Our primary independent variable of interest was dual use of VHA and fee-for-service Medicare for wound care. We identified wound care encounters in Medicare using the same set of ICD-9 codes originally used to identify subjects. For outpatient care, we required that one of the following Evaluation and Management codes for a scheduled office visit or urgent care visit



was present in the carrier or outpatient claims along with the ICD-9 code: 99201-99205, 99211-99215, 99241-99245, 99281-99285. For inpatient and long-term care, we included any hospital or skilled nursing claims that occurred within the study period and had at least one wound-related ICD-9 code. In order to appropriately classify the exposure (dual use of VHA and Medicare wound care), we identified the first date on which veterans had a Medicare claim with a wound-related ICD-9 code. Veterans were classified as dual users beginning with the time of their first Medicare visit and all times thereafter.

### *Wound outcomes*

We used a competing risk outcome defined as the earliest event of the following: wound healing, amputation, death or end of follow-up. A wound was considered healed at the VHA encounter when a provider stated it had completely re-epithelialized (i.e., no open areas or scab remained). Amputations were identified through the VHA medical record via surgery reports and confirmed with Medicare claims, where applicable, using amputation surgery codes. We used information about the first amputation that removed the wound and classified amputations as minor (toe or transmetatarsal) or major (transtibial or transfemoral). Veteran deaths were identified using the date of death from the VA medical record and confirmed using the Medicare denominator file.

### *Covariates and Adjustment*

We used several data sources to collect information on covariates. From the VHA electronic health record we recorded age, gender, marital status, zip code, service-connected

disability, comorbidity, and wound characteristics at baseline. From the Medicare denominator file, we recorded veterans' race and ethnicity category and the original reason for Medicare eligibility. We used the Area Health Resource file for county-level information about the number of non-federal patient care physicians, the number of hospital beds, and population size in 2006. We used the "vincenty" command in Stata to calculate the distance from each veteran's zip code center to the nearest VA facility based on latitude and longitude coordinates.

In descriptive tables, we report age as under 65 or 65+, while in the analytic model we included it as a continuous variable. Likewise, we report race/ethnicity categories in more detail in the descriptive tables (white, black, Asian, Native American, Hispanic, other, or missing) than we included in the propensity score model (indicators only for white, non-Hispanic and black, non-Hispanic race/ethnicity.) We classified veterans as married or not married at baseline. 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. We categorized veterans' service-connected disability (SCD) rating as either below 50% (including not SCD eligible) and 50-100% to reflect priority status within VHA [20].

We used VHA physician progress notes and the "Problem List" to determine whether veterans had any of the following thirteen 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. Veterans with higher comorbidity are more likely to use multiple health

care systems [6] and each of these conditions could be expected to influence wound healing [21–25]. To limit the number of covariates in our models, we counted 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 [26]. The maximum possible comorbidity score was 14. We also recorded whether or not veterans had ever had a lower limb wound or amputation before the study.

For each wound, we classified the etiology based on ICD-9 diagnosis codes and VHA provider chart notes. 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 at baseline we classified whether the wound had exposed bone, tendon, or joint or evidence of osteomyelitis (bone infection).

### *Statistical analysis*

We used proportional hazards models with a time-varying measure of exposure (dual wound care use) to calculate hazard ratios (HR) for wound healing, accounting for the competing risks of amputation or death [27]. Time was defined as days of follow-up beginning 30 days after baseline since all wounds had a minimum duration of 30 days by study definition. We used a competing risks approach because patients 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 [22,23]; therefore, standard

approaches to estimating hazard ratios, like Cox proportional hazards regression, would be inappropriate since they assume that censoring is independent of the time to event.

We compared dual users to VHA exclusive users, using a time-varying exposure such that veterans were classified as exposed (dual users) from the time of their first Medicare visits and at all times thereafter, accounting for multiple records per person, and adjusting for potential confounders using the propensity score and propensity score squared as the sole covariates in the competing risks models. We also used repeated all analyses using the IPTW weighted sample. An HR>1 indicates a higher rate of healing among dual users compared to VHA-exclusive users. We tested whether proportional hazards assumptions for the models were satisfied using Schoenfeld residual plots, and we used delta beta plots to identify influential subjects [28]. We plotted cumulative incidence curves to display overall time to healing for VHA-exclusive users and dual users, adjusted for covariates [29].

We applied estimated propensity score adjustment to account for baseline differences across exposure groups [30,31]. We selected this approach because we were interested in adjusting for a broad range of covariates but had a relatively small sample size. We derived propensity scores by estimating a logistic regression model and generating the predicted probability of being a dual user as a function of the covariates described above. We based the model on existing literature [6,9,21–23] and included interactions between comorbidity score and wound etiology and between rural residence and each of the physician supply variables [32]. Once we estimated propensity scores, we also used them to calculate inverse probability of treatment weights (IPTW) for the sample, using the formula  $IPTW = \frac{\text{treatment}}{\text{propensity score}} + \frac{(1-\text{treatment})}{(1-\text{propensity score})}$ , where treatment was equal to 1 for dual users

and 0 for VHA-exclusive users. [33]. We used the standardized difference, calculated using the Stata user-created command “pbalcheck,” to assess covariate balance in the original sample and in the samples weighted by propensity score and IPTW [33]. All analyses were conducted in Stata 13.1 (College Station, TX).

### *Sensitivity Analyses*

We planned four sensitivity analyses *a priori*. First, exclusively using VHA data to establish the wound resolution dates might result in bias among dual users. Specifically, a veteran who used Medicare wound care may have less VHA utilization and time to healing may be overestimated as a result. To address this issue, we estimated competing risk models after reassigning wound resolution dates for dual users based on the date of the last visit on which a wound-related claim (relevant ICD code) appeared in Medicare. The second sensitivity analysis excluded veterans who were enrolled in a Medicare managed care plans at any point during their wound episode. Visits paid for by a Medicare managed care plans do not appear as Medicare claims so including veterans enrolled in these plans might result in misclassification of veterans as VHA-exclusive users. Third, during the study period the Walla Walla VA Medical Center was participating in an intervention designed to improve wound care [17,18] and therefore may have provided different wound care than other sites, so we excluded veterans who received care at the Walla Walla VA Medical Center. Finally, we conducted sensitivity analyses in which we excluded VHA-exclusive subjects with estimated propensity scores that were outside the range of the dual users’ scores to assure the comparison groups were similar.

## Results

### *Veteran and wound characteristics*

Forty-one veterans (18.1%) were classified as dual wound care users at some time during follow-up and 186 were classified as VHA-exclusive wound care users throughout follow-up. The average age of both dual users and Medicare-eligible VHA-exclusive users at baseline was 69 years. The demographic, health, and zip-code based health supply characteristics of both groups of veterans were similar (Table 1). Nearly half of dual users and about one in three VHA-exclusive users had a previous LL wound that healed and 19% of dual users and 27% of VHA-exclusive users 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. Weighting the sample by either the propensity score or IPTW general resulted in better balance across covariates, including wound etiology (Table 1). Dual users had higher estimated propensity scores, on average, than VHA-exclusive users (mean=0.33, SD=0.23 for dual users; mean=0.15, SD=0.13 for VHA-exclusive users). Estimated propensity scores ranged from 0.07-0.99 for dual users and 0-0.55 for VHA-exclusive users. Likewise, IPTWs were higher for dual users, on average, than for VHA-exclusive users (mean=4.91, SD=3.67 for dual users; mean=1.21, SD=0.23 for VHA-exclusive users). IPTWs ranged from 1-13.88 for dual users and 1-2.22 for VHA-exclusive users.

### *Wound outcomes*

During one year of follow up, 48.8% of dual users' (n=20) and 77.9% (n=145) of VHA-exclusive users' wounds healed, 14.6% (n=6) of dual users and 5.9% (n=11) of VHA-exclusive users underwent amputation, and 14.6% (n=6) of dual users and 5.9% (n=11) of VHA-exclusive users died with active wounds. The remaining 21.9% (n=9) of dual users' and 10.2% (n=19) VHA-exclusive users' wounds were unresolved after one year of follow-up. In the unadjusted competing risks proportional hazards model, dual wound care use was associated with statistically significantly lower wound healing (HR=0.55, 95%CI: 0.35-0.85, p=0.007).

After covariate adjustment using estimated propensity scores (PS), dual use was associated with significantly poorer wound healing compared to VHA-exclusive use (HR=0.63, 95%CI: 0.39-0.99; Table 2). In the IPTW model, results were similar but not statistically significant (HR=0.65, 95%CI: 0.39-1.06). Figure 1 illustrates the lower cumulative incidence of wound healing among dual users than among VHA-exclusive users. The median time to healing from the baseline visit was 205 days (95%CI: 173-230) for dual users and 117 days (95%CI: 104-129) for VHA-exclusive users. Dual users were significantly more likely than VHA-exclusive users to undergo amputation (PS-adjusted HR=4.23, 95%CI: 1.61-11.15,; IPTW HR=4.04, 95%CI: 1.16-14.09) or to die with an active wound (PS-adjusted HR=3.08, 95%CI: 1.11-8.56; IPTW HR=2.88, 95%CI: 0.80-10.29). Median time to amputation was 149 (95%CI: 36-319) days after baseline among dual users and 91 (95%CI: 39-272) days among VHA-exclusive users. Most amputations were minor, both among dual users (67%) and among VHA-exclusive users (64%). 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*

In all four sensitivity analyses, the association between time-varying dual use and wound healing was similar to the main analysis. Point estimates for amputation and death were in the same direction (i.e., HRs>1), but varied across analyses and were not always statistically significant. We report results for the propensity-score adjusted models below; results from IPTW models were slightly attenuated in comparison and had wider confidence intervals and larger p-values.

There were 14 (34.1%) 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 stronger association between time-varying dual use and wound healing (HR=0.43, 95%CI: 0.26-0.70, p=0.001) but attenuated hazard ratios for amputation (HR=2.78, 95%CI: 1.04-7.28, p=0.041) and death (HR=1.88, 95%CI: 0.62-5.75, p=0.27). Excluding veterans who were enrolled in Medicare managed care plans at any time during their wound episode (n=24 excluded; 1 (2.4%) dual user and 23 (12.4%) VHA-exclusive users) resulted in a similar HRs for wound healing (HR=0.60, 95%CI: 0.38-0.96, p=0.032), amputation (HR=4.29, 95%CI: 1.60-11.45, p=0.04) and death (HR=3.34, 95%CI: 1.15-9.69, p=0.026). When we excluded veterans who received care at the Walla Walla VHA (n=17; 7 dual users (17.1%) and 10 (5.4%) VHA-exclusive users), the results were similar for wound healing (HR=0.63, 95%CI: 0.39-1.01, p=0.055) and were attenuated for amputation (HR=2.42, 95%CI: 0.70-8.33, p=0.16) and death (HR=3.07, 95%CI: 1.08-8.70, p=0.035).

When we restricted the analyses to veterans with estimated propensity scores  $\geq 0.07$  (the lowest value for a dual user; n=58 VHA-exclusive users excluded), point estimates were



nearly the same as those in the main analysis for wound healing (HR=0.61, 95%CI: 0.38-0.97, p=0.035), but higher for amputation (HR=6.35, 95%CI: 2.14-18.91, p=0.001) and lower for death (HR=2.84, 95%CI: 1.02-7.91, p=0.045).

## **Discussion**

Among patients with incident lower limb wounds, dual users of VHA and Medicare health services for follow-up wound care had significantly poorer wound healing relative to exclusive users of VHA follow-up wound care. This association was robust to adjustment for veteran demographic, health, and wound characteristics and to several sensitivity analyses. However, it was not statistically significant when we used IPTW methods for adjustment. 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 Medicare-eligible veterans, for which all health service utilization within VHA and Medicare was likely to be observed. These findings are consistent with other studies that have found poorer outcomes among dual system users [2,10,34]: Helmer et al. found that Veterans with diabetes who used both VHA and Medicare had higher hemoglobin A1c levels compared to VHA-exclusive users, indicating poorer glycemic control for dual users [10]. Most veterans in this study had diabetes, and this poor control could have contributed to poorer wound outcomes. Veterans exclusively using VHA health services benefit from elements of an integrated health care system including an electronic health record accessible to all providers in the system. Our results suggest that veterans who choose to receive follow-up wound care from VHA and other non-VA sources exhibit worse wound healing outcomes potentially resulting from worse coordination of care.

Although not a primary outcome in this study, we found higher levels of outpatient wound care for dual users (average 11 visits per dual user compared to 7.5 per VHA-exclusive user), consistent with previous studies of dual system use [10,25]. The average number of VHA outpatient visits was similar for veterans in each group. Therefore, we do not believe the difference in wound outcomes is attributable to less frequent care among dual users.

There are several limitations to this study. The first relates to differences between our data sources. As described by Burgess et al., the purpose of an administrative dataset influences the information contained in that dataset and its utility in research [35]. In this study, we relied heavily on VHA data and did not include wound care paid for through sources other than VHA and Medicare, which may have underrepresented utilization and complexity across systems [11,36] and could have biased our results. Also, 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 and did not include veterans who receive all of their wound care outside of VHA, including Medicare-exclusive users. This sampling approach may explain why a smaller proportion of veterans included in our study were dual users (18%) compared to other studies (as high as 50%) [2–4]. The interpretation of our findings is limited somewhat by the small number of dual wound care users and the resulting imprecision in estimates related to amputation and death. Also, some covariates remained poorly balanced after propensity score or IPTW weighting, which could have resulted in residual confounding. Finally, the data used in this study are from 2006-2008 and it is possible that practice within VA and Medicare could have changed since they were collected,

though we are not aware of any systematic efforts to improve wound care or coordination across VHA and Medicare since the study period.

Our findings have potential implications for the organization of wound care within VHA. Previous studies have demonstrated that highly coordinated care and regular follow-up are important for reducing amputations and speeding wound healing [14,16]. If single-system use is better for veterans, VHA may need to consider designing programs or policies that support exclusive VHA utilization for chronic wound care. VHA's Patient-Aligned Care Teams (PACT), the patient-centered medical home program that involves team-based and coordinated care [37,38], might be tailored to deliver high quality wound care, for example [39]. Future research should examine whether specific elements of PACT, including those related to coordinated care, are associated with improved wound healing [40]. Additional work is needed to replicate our findings and to establish more precise estimates. Also, 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 the observed difference in wound healing for dual users. These factors may be useful targets for interventions to reduce the negative outcomes associated with dual use.

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Dr. Wong reports ownership of common stock in UnitedHealth Group Inc., Community Health Systems Inc. and Quorum Health Corp. The authors have no other potential conflicts of interest to disclose.

## **List of Abbreviations**

VHA Veterans Health Affairs

LL Lower limb

HR Hazard ratio

SCD Service connected disability

ESRD End-stage renal disease

PS Propensity score

IPTW Inverse probability of treatment weights

PACT Patient aligned care team

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## Tables

Table 1. Baseline demographic, health, and wound characteristics of veterans with chronic lower limb (LL) wounds and area level health supply characteristics by Medicare-VHA dual wound care use in overall sample and in samples weighted by propensity score and inverse probability of treatment weights.

Variable	Category	Original sample			PS-weighted sample		
		Medicare-VHA dual users (n=41)	VHA-exclusive users (n=186)	Standardized difference	Medicare-VHA dual users (n=41)	VHA-exclusive users (n=186)	Standardized difference
		%	%		%	%	
Age (years)	≥65	63.4	67.2	0.07	65	61	0.09
Gender	Male	95.1	98.9	0.23	94	98	0.23
Marital status	Married	43.9	54.8	0.28	34	48	0.28
Race/ethnicity	White	92.7	91.9	0.01	83	97	0.50
	Black	7.3	3.8	0.17	17	3	0.58
	Asian	0	1.1	0.21	0	0	0
	Native American/Alaska Native	0	0.5	0.15	0	0	0
	Hispanic	0	0.5	0.10	0	0	0
	Other	0	2.1	0.10	0	0	0
Rural residence	Yes	53.7	53.2	0.04	55	52	0.05
Service-connected disability	50-100%	34.1	32.8	0.01	35	32	0.06
Original reason for Medicare eligibility	Disability before age 65	61.0	50.5	0.17	63	59	0.09
Health conditions	Diabetes	61.0	58.1	0.02	60	56	0.08
	Diabetes complication	43.9	49.5	0.17	36	49	0.25
	Peripheral artery disease	53.7	53.2	0.04	59	52	0.14
	Cancer	17.1	14.5	0.09	16	15	0.02

	Cerebrovascular disease	19.5	21.5	0.02	21	23	0.05
	Congestive heart failure	21.9	28.5	0.19	26	29	0.08
	Connective tissue disease	4.9	4.3	0.04	2	4	0.07
	Coronary artery disease	46.3	41.9	0.08	45	39	0.12
	Hypertension	78.0	84.4	0.19	83	83	0.02
	HIV/AIDS	0	0	--	0	0	--
	Liver disease	0	3.2	0.26	0	3	0.27
	Lower limb paralysis	14.6	5.9	0.31	17	8	0.28
	Myocardial infarction	26.8	16.1	0.23	25	16	0.23
	Renal disease	19.5	29.0	0.33	15	27	0.29
	Comorbidity score, mean	4.0	4.1	0.07	4.1	4.0	0.002
LL history	Prior LL wound	58.5	58.6	0.008	54	60	0.13
	Prior LL amputation	19.5	26.9	0.21	11	24	0.30
Wound etiology	Arterial	29.3	16.1	0.29	31	27	0.11
	Diabetic	21.9	29.6	0.21	11	27	0.36
	Neuropathic	4.9	2.7	0.13	9	3	0.28
	Venous	14.6	24.2	0.22	9	18	0.21
	Pressure	14.6	9.1	0.19	16	14	0.07
	Infectious	4.9	8.1	0.12	2	6	0.19
	Other	4.9	7.0	0.08	6	5	0.05
	Mixed <sup>±</sup>	4.9	3.2	0.09	15	0	0.77
Baseline wound characteristics	Complex anatomy at wound site§	21.9	32.8	0.22	17	25	0.17
	Exposed bone, tendon, or joint or osteomyelitis	9.7	8.1	0.08	10	10	0.008
Total non-federal patient care	Mean (SD)	1.9	1.9	0.01	1.9	1.9	0.03

physicians per 1,000 population							
Number of hospital beds available per 1,000 population	Mean	2.3	2.4	0.04	2.5	2.3	0.10
Distance to nearest VHA facility (miles)	Mean	12.3	15.8	0.21	10.4	13.2	0.17

VHA: Veterans Health Administration

PS: Propensity score

IPTW: Inverse probability of treatment weight

§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 2. Adjusted competing risks proportional hazards regression results for wound healing, amputation, and death in models adjusted for estimated propensity scores<sup>§</sup> and weighted using inverse probability of treatment weights<sup>‡</sup> among Veterans with chronic lower limb wounds.

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
Propensity Score Models <sup>§</sup>						
VHA-exclusive (n=186 veterans)	Reference		Reference		Reference	
Dual use (n=41 veterans)	0.63 (0.39-0.99)	0.047	4.23 (1.61-11.15)	0.003	3.08 (1.11-8.56)	0.031
Inverse Probability Weight Models <sup>‡</sup>						
VHA-exclusive (n=186 veterans)	Reference		Reference		Reference	
Dual use (n=41 veterans)	0.65 (0.39-1.06)	0.081	4.04 (1.16-14.09)	0.028	2.88 (0.80-10.29)	0.10

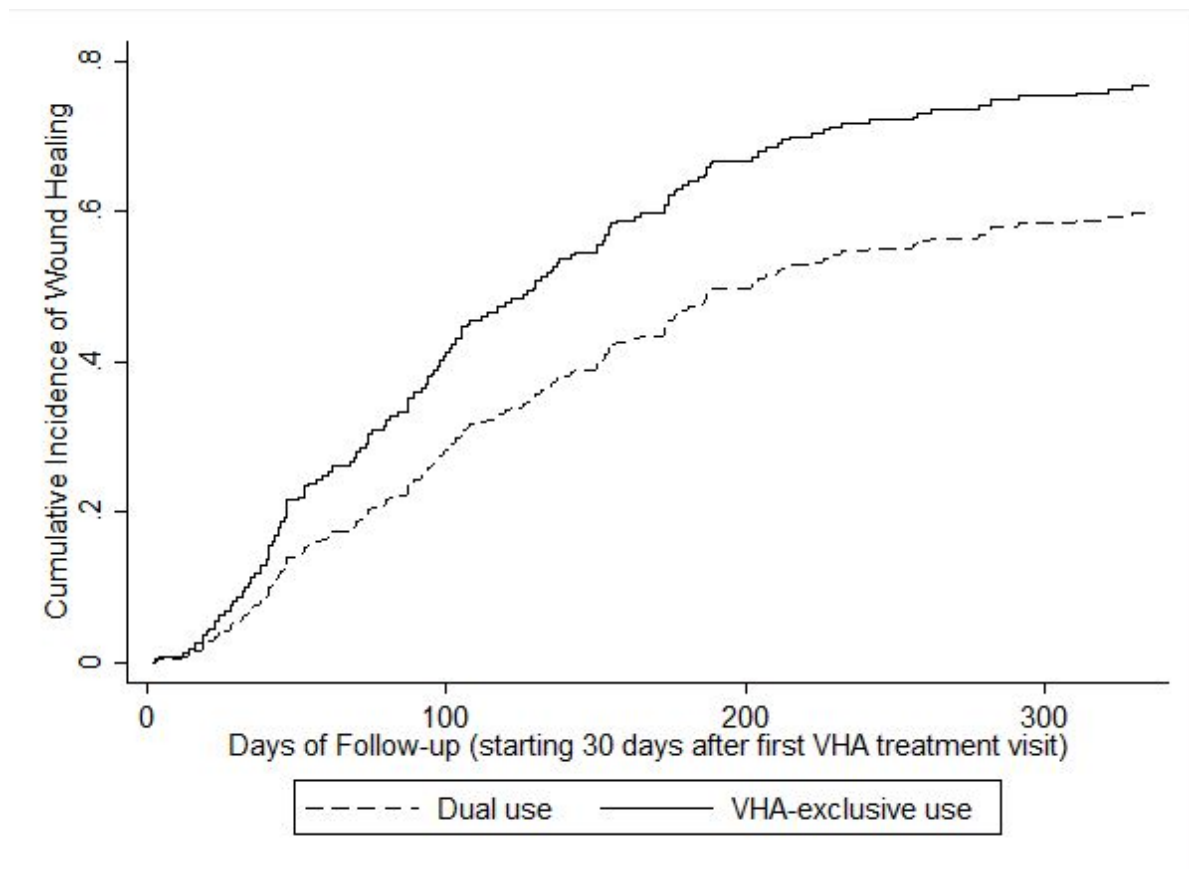
<sup>§</sup>Propensity score models included estimated propensity score and propensity score squared.

Propensity scores were estimated from a logistic regression model including age, white race and non-Hispanic ethnicity, black race and non-Hispanic ethnicity, married, service connected disability  $\geq 50\%$ , prior lower limb wound, prior lower limb amputation, complex anatomy at

wound site, baseline wound severity (exposed bone, joint, or tendon), an interaction between comorbidity score and wound etiology, and interactions between rural residence and three health care supply variables (total non-federal patient care MDs per 1,000 population in zip code, total hospital beds per 1,000 population in zip code, and distance to nearest VA).

<sup>‡</sup>Inverse probability weights were calculated using the propensity score calculated as described for the propensity score-adjusted models.

Figure 1. Cumulative incidence of chronic lower limb wound healing among veterans who used both VHA and Medicare (dual users) and those who used VHA exclusively in VISN 20 from October 1, 2006-September 30, 2007 based on a competing risks proportional hazards model<sup>‡</sup> using a time-varying classification of dual use.



<sup>‡</sup>Adjusted for: estimated propensity score and propensity score squared. Propensity scores were estimated from a logistic regression model including age, white race and non-Hispanic ethnicity, black race and non-Hispanic ethnicity, married, service connected disability  $\geq 50\%$ , prior lower limb wound, prior lower limb amputation, complex anatomy at wound site, baseline wound severity (exposed bone, joint, or tendon), an interaction between comorbidity score and

wound etiology, and interactions between rural residence and three health care supply variables (total non-federal patient care MDs per 1,000 population in zip code, total hospital beds per 1,000 population in zip code, and distance to nearest VHA).





