JRRD Volume 52, Number 6, 2015
Pages 641–652

Predicting prosthetic prescription after major lower-limb amputation

Linda Resnik, PT, PhD, OCS;[1–2*] Matthew Borgia, AM[1]
[1]Providence Department of Veterans Affairs Medical Center, Providence, RI; [2]Department of Health Services Policy and Practice, Brown University, Providence, RI

Abstract—We describe prosthetic limb prescription in the first year following lower-limb amputation and examine the relationship between amputation level, geographic region, and prosthetic prescription. We analyzed 2005 to 2010 Department of Veterans Affairs (VA) Inpatient and Medical Encounters SAS data sets, Vital Status death data, and National Prosthetic Patient Database data for 9,994 Veterans who underwent lower-limb amputation at a VA hospital. Descriptive statistics and bivariates were examined. Cox proportional hazard models identified factors associated with prosthetic prescription. Analyses showed that amputation level was associated with prosthetic prescription. The hazard ratios (HRs) were 1.41 for ankle amputation and 0.46 for transfemoral amputation compared with transtibial amputation. HRs for geographic region were Northeast = 1.49, Upper Midwest = 1.26, and West = 1.39 compared with the South ($p < 0.001$). African American race, longer length of hospital stay, older age, congestive heart failure, paralysis, other neurological disease, renal failure, and admission from a nursing facility were negatively associated with prosthetic prescription. Being married was positively associated. After adjusting for patient characteristics, people with ankle amputation were most likely to be prescribed a prosthesis and people with transfemoral amputation were least likely. Geographic variation in prosthetic prescription exists in the VA and further research is needed to explain why.

Key words: amputation, amputee, assistive technology, limb loss, lower limb, prescription, prosthetics, regional variation, rehabilitation, Veteran.

INTRODUCTION

The use of a lower-limb prosthesis can enhance mobility, independence, safety, and quality of life in people with lower-limb amputation [1–3]. Prosthesis use can contribute to more active lifestyles, helping users reduce their risk for secondary outcomes such as overuse problems, changes in gait, further vascular damage, and subsequent amputations [4–5]. Generally speaking, prescription of a lower-limb prosthesis is considered appropriate for persons with the potential to return to ambulation, although they are also indicated to improve safety in standing, transferring, and stationary activities as well as to improve cosmesis [6]. However, not all people with amputation are candidates for prosthetic prescription. The determination

Abbreviations: HCPCS = Healthcare Common Procedure Coding System, HR = hazard ratio, ICD-9-CM = International Classification of Diseases-9th Revision-Clinical Modification, MedSAS = Inpatient and Medical Encounters SAS data sets, NPPD = National Prosthetic Patient Database, OEF = Operation Enduring Freedom, OIF = Operation Iraqi Freedom, PTF = Patient Treatment File, TF = transfemoral, TT = transtibial, VA = Department of Veterans Affairs, VISN = Veterans Integrated Service Network.

*Address all correspondence to Linda Resnik, PT, PhD, OCS; Providence VA Medical Center, 830 Chalkstone Ave, Providence, RI 02908; 401-273-7100, ext 2368.
Email: Linda.Resnik@va.gov

http://dx.doi.org/10.1682/JRRD.2014.09.0216

of appropriateness for prosthetic prescription is a multidisciplinary team decision in the Department of Veterans Affairs (VA), based on a thorough evaluation of the patient's medical and cognitive status and factors such as wound healing, residual limb health, contralateral limb health, and rehabilitation goals [6].

The VA policy for providing prosthetic devices states that Veterans can receive any "reasonable and necessary device," regardless of price, as long as a VA physician prescribes it [7]. The VA will provide additional recreational devices or components if the prosthesis worn daily is unsuitable for recreational activity. Furthermore, the VA policy is implemented on a national level. Thus, VA beneficiaries are not limited in access to devices for financial reasons.

Between 2005 and 2009, the VA spent more than $414 million on artificial limbs, with wide variation in all types of prosthetic expenditures by Veterans Integrated Service Network (VISN). For example, during the same period, the New England region (VISN 1) had $251 million in expenditures while the Sunshine Health Network (VISN 8) spent $607 million [8]. These variations are likely attributable to differences in the size and health of the patient population, but they may also be related to differences in practice patterns across the country.

Data from several retrospective studies and several cohort studies in the United States [9–14] and abroad [15–22] show that the rates of prosthetic fitting vary by amputation level, with 1 yr prescription rates ranging from 49 to 93 percent for people with transtibial (TT) amputation, 14 to 57 percent for transfemoral (TF) amputation, 38 to 67 percent for knee disarticulation, and 38 to 100 percent for below-ankle amputation. However, these studies vary in their sampling frame and inclusion and exclusion criteria, and it is not possible to generalize findings to all persons who underwent major limb amputation in the United States or in the VA system.

Only a few studies report rates of prosthetic prescription within the VA [8,10–12,23]. Webster et al. reported the highest rates of prosthetic prescription in any study for patients in a prospective cohort that included 87 persons from a single VA medical center with diabetes or peripheral vascular disease who were ambulatory prior to amputation (93% TT, 57% TF) [10]. Nehler et al. reported that in a retrospective cohort study of 154 persons with major lower-limb amputation completing rehabilitation at the University of Colorado Health Sciences Center and the Denver VA Medical Center, 43 percent with TT amputation and 10 percent with TF amputation were fit with a prosthesis within 10.3 mo and 52 percent with TT amputation and 19 percent with TF amputation were fit within 17.5 mo [11]. Findings from these studies cannot be generalized to the broader amputation population or other VA medical centers. Reiber et al. surveyed people with traumatic amputation from the Vietnam war and Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) and reported prosthetic use by 78.2 percent of Vietnam war and 90.5 percent of OIF/OEF Veterans [23]. However, their study did not report on length of time to first prescription of a device and included only people with traumatic amputation from these conflicts; thus, findings cannot be generalized to all Veterans with lower-limb amputation. To our knowledge, only one prior study used data from all VA medical centers to estimate the annual rates of prosthetic prescription for people with lower-limb amputation who were prosthetic users [24]. However, that study did not examine the prosthetic prescription rates for people with amputation in their first year after surgery and did not compare rates of prescription for people with incident amputation by level of amputation.

Early prosthetic prescription has many physical and psychological benefits. It can facilitate maturation of the residual limb and adaptation of the residual limb to the definitive socket as well as facilitate more normal gait, better acceptance of the amputation, and better body image [25]. Thus, understanding sources of variation in rates of initial prosthetic prescription may help improve patient care.

Prior research on receipt of rehabilitation services after major lower-limb amputation in the VA reported that differences existed in access to physical therapy and occupational therapy by amputation level, geographic region, and hospital bed size [26–27]. We hypothesized that similar differences by amputation level and geographic region might be observed in receipt of prosthetic care. No national data on the prosthetic prescription rates for people with lower-limb amputation are currently available. Therefore, the purposes of our study were to describe prosthetic limb prescription in the first year following lower-limb amputation and examine the associations between level of amputation, geographic region, and prosthetic prescription.

METHODS

Data Sources

The study used data from the Patient Treatment File (PTF) databases of the Veterans Health Administration. These data are used to track the healthcare utilization of Veterans. The VA Vital Status file was used to identify Veterans who died during the study period. The PTF contains data on inpatient services. The databases included the Inpatient and Medical Encounters SAS data sets (MedSAS), including the data set containing information on demographics, diagnoses, and length of stay; the bed section data set containing information on managing physician specialty; the procedure data set containing inpatient stay procedure codes; and the surgery data set containing codes for all surgical procedures. Records of billable professional services received by patients during their inpatient stay were contained in the MedSAS. Data on prosthetic prescription were obtained from the VA's National Prosthetic Patient Database (NPPD), which contains all transaction-level data for orthotics, prosthetics, sensory devices, and surgical implants dispensed to Veterans nationwide. A common patient identifier allowed linkage of records across data sets.

Sample

Patients who had a major surgical amputation of the lower limb at any VA medical center between January 1, 2005, and December 31, 2009, were included. International Classification of Diseases-9th Revision-Clinical Modification (ICD-9-CM) procedure codes of 84.12 to 84.17 were used to identify major lower-limb amputations. ICD-9-CM procedure codes were used to determine level of amputation, which were classified as ankle (84.13–84.14), TT (84.15), or above or at knee (84.16–84.17). Patients with only toe amputations were excluded, and patients with disarticulation of the hip or abdominopelvic amputation were excluded because of low incidence rates.

A 12 mo look back period was utilized to limit the sample to first-time amputation. We used data from 2004 to 2009 and "looked back" a year for any record of lower-limb amputation. When evidence of an amputation surgery was identified, data from that hospitalization error were extracted. We found 10,454 patients who met the 12 mo look back criteria.

Death data from the main MedSAS and the Vital Status master file were used to ascertain death dates for the sample. We excluded 509 patients who died between their incident amputation date and hospital discharge and 1 patient with death data indicating death prior to amputation. Because prostheses are not indicated for some people with ankle amputation with anterior procedures, we excluded 2,254 persons who had ICD-9-CM codes of 84.12 from the final sample. The final sample consisted of 7,690 persons.

We utilized the Healthcare Common Procedure Coding System (HCPCS) associated with each NPPD item to identify the first date of prescription of lower-limb prosthesis for each patient. Our classification of the HCPCS variable is specified in the **Appendix** (available online only). In the NPPD, the type of order is a variable indicating whether or not the item was a new issue or a repair order. Because device prescription was our main outcome of interest, we only counted new items and did not count HCPCS prosthetic items listed as "rental" and "repair."

Key Covariates

Amputation level was determined by the same procedure codes used to determine whether a major surgical amputation occurred. Hospital geographic region was categorized into four regions: Northeast, South, Upper Midwest, and West.

Other Covariates

We examined patient demographics and other characteristics, including length of stay, number of comorbidities, age, sex, race, reamputation, amputation level, death date, living arrangement prior to hospitalization, marital status, and hospital bed size. Length of stay was calculated from admission and discharge dates. Data on age and sex were obtained from the main PTF data set.

Reamputation was defined as any subsequent major lower-limb amputation within 1 yr of the incident amputation surgical date. We created a death indicator variable for subjects who died within 1 yr of amputation (after excluding those who died before hospital discharge). Living location prior to the hospitalization for amputation surgery (admission source) was categorized as nursing home, hospital, or community. Information on marital status was extracted from the PTF MedSAS and categorized as single, married, divorced, widowed, or unknown.

Data on race were obtained from the PTF main data set and categorized as white, African American, other, or missing/unknown. Because race was missing for almost 40 percent of the sample (which is a known problem in VA data after 2003) [28–29], we extracted information on race from the most recent nonmissing race information located in the VA outpatient MedSAS from the years 1998 to 2002. Using this approach, we decreased the percentage of patients with missing information to 14.5 percent.

We used the Healthcare Cost and Utilization Project's Elixhausen comorbidity software (version 2.1 for years 2005–2007 and version 3.7 for years 2008–2010) to control for the number of comorbid conditions [30]. This software calculates the number of comorbidities using the ICD-9-CM diagnosis codes. Comorbidities in the Elixhausen include peripheral vascular disease, hypertension, paralysis, neurological disorders, chronic pulmonary disease, diabetes with chronic complications, diabetes without chronic complications, hypothyroidism, renal failure, liver disease, peptic ulcer disease, acquired immune deficiency syndrome, lymphoma, metastatic cancer, solid tumor without metastasis, rheumatoid arthritis, coagulopthy, obesity, weight loss, fluid and electrolyte disorder, chronic blood loss anemia, deficiency anemia, alcohol abuse, drug abuse, psychoses, and depression. In this approach, diabetes with complications and diabetes without complications were counted only once and metastatic cancer or solid tumor without metastasis were counted only once.

We examined several individual comorbidities, including congestive heart failure, peripheral vascular disease, paralysis, other neurological disorders, diabetes, and renal failure. The classification of hospital bed size was less than 126, 127 to 244, 245 to 362, and more than 362 beds.

Statistical Analyses

Descriptive statistics were used to examine key demographic variables, and bivariate *t*-test and chi-square analyses were used to examine differences in characteristics between those who received a prosthesis within 1 yr and those who did not. Raw frequencies were used to describe the proportion of subjects who received any lower-limb prosthetic item during the study period. Univariate Cox proportional hazard models found that all covariates (as listed previously) were associated with time to prescription with $p \leq 0.10$ except for sex.

A Cox proportional hazard regression analysis was used to determine the association between time to prosthetic prescription and the key independent variables of amputation level, geographic region, and prosthetic prescription. Time to event (prosthetic prescription) was calculated from the date of the incident amputation surgery, and data of subjects were censored in case of death or at 1 yr after surgery. All covariates except sex were used to control for significant predictors of prosthetic prescription. To validate the proportional hazards assumption, we used Kaplan Meir curves and log-log plots. Statistical analyses were done using SAS Enterprise Grid software (version 5.1, SAS Institute Inc; Cary, North Carolina).

RESULTS

Table 1 shows descriptive statistics. Subjects were 98.9 percent male, mostly white, and on average 66.3 yr old. Almost six percent of subjects had ankle-level amputations while 52.3 percent had TT and 41.9 percent had above or at knee-level amputation. Almost twenty-two percent of subjects had a reamputation within 12 mo (84% among ankle, 24% among TT, and 10% among TF). Subjects were fairly evenly distributed throughout the Northeast, Upper Midwest, and West (17.1%, 21.0%, and 19.3%, respectively), whereas 42.6 percent of patients were from the South. **Table 2** shows the proportion of people with amputation who received a prosthetic prescription by amputation level and geographic region.

Bivariate analyses show that the group of subjects who received prostheses within 1 yr of amputation had significantly shorter hospital inpatient stays, were younger, and had fewer comorbidities (**Table 3**). A higher proportion had TT amputations, were admitted from the community, were married or divorced (as compared with single), and had their surgeries at smaller hospitals.

Table 4 shows the mean time to prosthetic prescription for those patients who received a device by level and geographic region. On average, persons who received a device obtained one in 144.8 d. On average, subjects with above- or at-knee amputations received their devices 4 d before subjects with TT amputations and 7 d before subjects with ankle amputations. Subjects in the South received prosthetic prescription 14 to 32 d later than subjects from all other geographic regions, on average.

The adjusted Cox proportional hazard model (**Table 5**) revealed that amputation level was significantly positively associated with prosthetic prescription (TF hazard ratio [HR]: 0.46, $p < 0.001$, and ankle HR: 1.41, $p < 0.001$) compared with TT amputation. Geographic region was also associated with prosthetic prescription, with rates higher in the Northeast (HR: 1.49, $p < 0.001$), Upper Midwest (HR: 1.26, $p \leq 0.001$), and West (HR: 1.39, $p < 0.001$) than in the South. Longer length of stay (HR: 0.99, $p < 0.001$) and

Table 1.
Characteristics of subjects with incident amputations from January 1, 2005, to December 31, 2009 (N = 7,690).

Covariate	Mean ± SD or n (%)
Continuous	
Length of Stay (d)	19.6 ± 28.0
Hospital Stay Prior to Surgery (d)	7.0 ± 16.6
Hospital Stay After Surgery (d)	14.0 ± 18.4
Elixhausen Score	3.2 ± 1.6
Age (yr)	66.3 ± 11.2
Categorical	
Sex	
Female	85 (1.1)
Male	7,605 (98.9)
Race	
African American	1,775 (23.1)
Other	100 (1.3)
Unknown	1,113 (14.5)
White	4,702 (61.1)
Amputation Level	
Ankle	447 (5.8)
Transtibial	4,020 (52.3)
Above or At Knee	3,223 (41.9)
Reamputation	1,680 (21.9)
Died Within 1 yr of Amputation	907 (11.8)
Admission Source	
Nursing	825 (10.7)
Hospital	3,528 (46.1)
Community	3,320 (43.2)
Marital Status	
Divorced	2,057 (26.8)
Married	3,126 (40.7)
Single	1,017 (13.2)
Unknown	701 (9.1)
Widowed	789 (10.2)
Comorbidities	
Congestive Heart Failure	1,118 (15.4)
Peripheral Vascular Disease	4,765 (62.0)
Paralysis	547 (7.1)
Other Neurological Disease	418 (5.4)
Diabetes	4,789 (62.3)
Renal failure	1,405 (18.3)
Region	
Northeast	1,313 (17.1)
Upper Midwest	1,616 (21.0)
West	1,482 (19.3)
South	3,279 (42.6)
Bed Size (n)	
≤126	2,501 (32.5)
127–244	2,716 (35.3)
245–362	2,062 (26.8)
>362	411 (5.3)

SD = standard deviation.

Table 2.
Frequency (%) of patients who received prosthetic prescription within 1 yr by geographic region and amputation level.

Region	Ankle (n = 447)	Transtibial (n = 4,020)	Transfemoral (n = 3,223)	All (N = 7,690)
Northeast	27 (56.3)	326 (46.5)	120 (21.3)	473 (36.0)
Upper Midwest	49 (49.0)	418 (47.5)	157 (24.7)	624 (38.6)
West	87 (55.8)	388 (47.0)	92 (18.4)	567 (38.3)
South	53 (37.1)	582 (36.1)	249 (16.4)	884 (42.6)
All	216 (48.3)	1,714 (42.6)	618 (19.2)	2,548 (33.1)

older age (HR: 0.98, $p < 0.001$) were negatively associated with receiving a prosthesis. African Americans were less likely to be prescribed a prosthesis than white patients (HR: 0.84, $p < 0.01$). Admission from a nursing facility (HR: 0.77, $p = 0.001$) was also negatively associated with receipt of a device compared with admission from a hospital. Being married was positively associated with prosthetic prescription compared with being single (HR: 1.23, $p = 0.001$). The diagnoses of congestive heart failure, peripheral vascular disease, paralysis, other neurological disease, and renal failure were negatively associated with prosthetic prescription ($p < 0.01$).

The Kaplan-Meier curves (**Figures 1–2**) were approximately parallel by stratum and support use of the Cox proportional hazards model. They illustrate the increased rates of prosthetic prescription in the Northeast, Upper Midwest, and West regions as compared with the South and the increased prosthetic prescription among patients with above- or at-knee and TT amputation as compared with ankle amputation.

DISCUSSION

Our study examined the rates of prosthetic prescription for Veterans who underwent amputation of a lower limb at VA hospitals between January 1, 2005, and December 31, 2009. We found racial variation in prosthetic prescription, with African-American patients less likely to be prescribed prostheses than white patients. To our knowledge, this is the first study to report a racial disparity in prosthetic prescription rates. Prior studies have shown that minority Veterans underutilized assistive technology benefits [31] and that severely disabled African-American Veterans were 60 percent less likely to utilize assistive technology than white Veterans.

Table 3.
Bivariate comparison of characteristics of persons who did and did not receive prosthetic prescription within 1 yr. Data reported as mean ± standard deviation or frequency (%).

Variable	Prosthetic Prescription		Total (*N* = 7,690)
	No (*n* = 5,142)	Yes (*n* = 2,548)	
Continuous			
Length of Stay (d)*	21.8 ± 31.9	15.0 ± 16.8	19.6 ± 28.0
Elixhausen Score*	3.3 ± 1.5	2.9 ± 1.6	3.2 ± 1.6
Age (yr)*	68.1 ± 11.2	62.6 ± 10.1	66.3 ± 11.2
Categorical			
Sex			
Female	53 (1.0)	32 (1.3)	85 (1.1)
Male	5,089 (99.0)	2,516 (98.7)	7,605 (98.9)
Race*			
White	3,124 (60.8)	1,578 (61.9)	1,775 (23.1)
African American	1,306 (25.4)	469 (18.4)	100 (1.3)
Other	61 (1.2)	39 (1.5)	1,113 (14.5)
Unknown	651 (12.7)	462 (18.1)	4,702 (61.1)
Amputation Level*			
Ankle	231 (4.5)	216 (8.5)	447 (5.8)
Transtibial	2,306 (44.9)	1,714 (67.3)	4,020 (52.3)
Above or At Knee	2,605 (50.7)	618 (24.3)	3,223 (41.9)
Reamputation	1,151 (22.4)	529 (20.8)	1,680 (21.9)
Died Within 1 yr of Amputation*	774 (15.1)	133 (5.2)	907 (11.8)
Admission Source*			
Nursing	637 (12.4)	188 (7.4)	825 (10.7)
Hospital	2,402 (46.8)	1,136 (44.6)	3,528 (46.1)
Community	2,098 (40.8)	1,222 (48.0)	3,320 (43.2)
Marital Status*			
Divorced	1,325 (25.8)	732 (28.7)	2,057 (26.8)
Married	2,034 (39.6)	1,092 (42.9)	3,126 (40.7)
Single	674 (13.1)	343 (13.5)	1,017 (13.2)
Unknown	501 (9.7)	020 (7.9)	701 (9.1)
Widowed	608 (11.8)	181 (7.1)	789 (10.2)
Comorbidities*			
Congestive Heart Failure	894 (17.4)	287 (11.3)	1,118 (15.4)
Peripheral Vascular Disease	3,358 (65.3)	1,407 (55.22)	4,765 (62.0)
Paralysis	508 (9.9)	39 (1.5)	547 (7.1)
Other Neurological Disease	343 (6.7)	75 (2.9)	418 (5.4)
Diabetes	3,151 (61.3)	1,638 (64.3)	4,789 (62.3)
Renal Failure	1,011 (19.7)	394 (15.5)	1,405 (18.3)
Region*			
Northeast	840 (16.3)	473 (18.6)	1,313 (17.1)
Upper Midwest	992 (19.3)	624 (24.5)	1,616 (21.0)
West	915 (17.8)	567 (22.3)	1,482 (19.3)
South	2,395 (46.6)	884 (34.7)	3,279 (42.6)
Bed Size (*n*)*			
≤126	1,504 (29.3)	997 (39.1)	2,501 (32.5)
127–244	1,804 (35.1)	912 (35.8)	2,716 (35.3)
245–362	1,525 (29.7)	537 (21.1)	2,062 (26.8)
>362	309 (6.0)	102 (4.0)	411 (5.3)

*$p < 0.05$.

Table 4.
Days until prosthetic prescription for Veterans with incident lower-limb amputation.

Patient Characteristics	*n*	Mean ± SD
Total	2,548	144.8 ± 81.9
Region		
South	884	159.7 ± 81.6
Northeast	473	144.0 ± 79.8
Upper Midwest	624	136.2 ± 78.5
West	567	151.7 ± 84.5
Amputation Level		
Ankle	216	148.7 ± 87.3
Transtibial	1,714	145.6 ± 82.6
Above or At Knee	618	141.3 ± 78.0

SD = standard deviation.

We also found variation in prosthetic prescription practices by geographic region, with prevalence of prescription lowest in the South as compared with other regions. The geographic variation we observed was consistent with findings regarding receipt of other types of rehabilitation services postamputation [26–27]. Resnik and Borgia reported that patients treated in VA hospitals in the Northeast had the lowest likelihood of receiving physical and occupational therapy and patients in the West had the highest likelihood as compared with patients seen in VA hospitals in the South [26]. Zhou et al. reported similar findings across the continuum of postamputation rehabilitation with lowest prevalence of services provided in the Northeast and highest prevalence in the Midwest and West [27]. Additional research is needed to identify the underlying causes of this geographic variation in practice pattern. However, the decreased likelihood of prosthetic prescription among African Americans that we observed in the current study was unexpected. No prior studies have examined disparities in receipt of prosthetic services postamputation. Thus, further research is necessary to identify the factors associated with reduced likelihood of prosthetic prescription in this population.

Those patients who did receive prostheses in the South received them, on average, 14 to 32 d later than those from other regions. This suggests that the VA medical centers in this region may not have sufficient capacity to meet the needs of their patients in a timely manner. Almost twice the number of VA patients in our sample were from the South as compared with any other region. Thus, we expect that the burden of costs for prosthetic care in South VA medical centers would be higher than in other regions, and it is possible that the South might be attempting to manage costs by being more conservative in their prosthetic prescription practices. Similar patterns of prosthetic prescription may exist outside of the VA system of care, and future research should examine whether this finding can be generalized to prosthetic prescription patterns in other settings.

We also found differences in prosthetic prescription rates by level of amputation, with patients who underwent foot and ankle amputation the most likely to be prescribed a device and patients with TF amputation the least likely. This finding is somewhat surprising, given that about half of persons with foot and ankle amputation experience problems with wound healing, ulceration, breakdown of the skin, and other postsurgical complications [32–33]. Persons with foot and ankle amputation are more likely to progress to amputation at a more proximal level than persons with TT and TF amputation. Using a national sample of Medicare beneficiaries, Dillingham et al. reported that 38.8 percent of people with foot and ankle amputation have at least one reamputation surgery within the first 12 mo as compared with 23 percent with TT amputation and 14 percent with TF amputation [34]. The majority of reamputations occur on the ipsilateral side, although about one-third occur on the contralateral lower limb [34]. In our sample, 22 percent of all patients had at least one reamputation within 12 mo, with rate varying by level (foot and ankle: 84%, TT: 24%, TF: 10%). Of those with reamputation, 87 percent had one, 11 percent had two, and 2 percent had three or more. We found that reamputation was negatively associated with likelihood of receipt of a prosthesis during the follow-up period.

Our study has several limitations. First, the analytic sample consisted of Veterans who had their amputation performed within a VA medical center. No attempt was made to include Veterans who had their surgeries at non-VA hospitals. Therefore, these results are not generalizable to Veterans with amputation whose surgeries were outside the VA who then later received prosthetic services at the VA. Second, our study used data from the NPPD to identify the presence of a prosthetic prescription and the date of that prescription and we had no method of validating the accuracy of this information. That said, there is no reason to expect that there would be

Table 5.
Cox proportional hazard model hazard ratios for prosthetic prescription (N = 7,683).

Variable	Hazard Ratio	95% CI	*p*-Value
Continuous			
Length of Stay	0.99	0.99–0.99	<0.001
Elixhausen Score	0.98	0.95–1.02	0.37
Age	0.98	0.97–0.98	<0.001
Categorical			
Race			
White (ref)	—	—	—
African American	0.84	0.76–0.94	0.001
Other	1.04	0.76–1.43	0.82
Unknown	1.19	1.07–1.32	0.001
Amputation Level			
Ankle	1.41	0.28–0.35	<0.001
Transtibial (ref)	—	—	—
Above or At Knee	0.46	1.20–1.65	<0.001
Reamputation	0.76	0.68–0.85	<0.001
Admission Source			
Nursing	0.77	0.66–0.90	0.001
Hospital (ref)	—	—	—
Community	1.03	0.95–1.12	0.51
Marital Status			
Divorced	1.12	0.98–1.28	0.09
Married	1.23	1.09–1.40	<0.001
Single (ref)	—	—	—
Unknown	0.94	0.79–1.12	0.52
Widowed	1.04	0.86–1.25	0.70
Comorbidities			
Congestive Heart Failure	0.81	0.71–0.93	0.002
Peripheral Vascular Disease	0.89	0.82–0.98	0.01
Paralysis	0.26	0.19–0.36	<0.001
Other Neurological Disease	0.73	0.58–0.92	0.008
Diabetes	0.96	0.87–1.05	0.34
Renal Failure	0.86	0.76–0.97	0.02
Region			
South (ref)	—	—	—
Northeast	1.49	1.33–1.67	<0.001
Upper Midwest	1.26	1.13–1.41	<0.001
West	1.39	1.24–1.55	<0.001
Bed Size			
≤126 (ref)	—	—	—
127–244	0.80	0.73–0.87	<0.001
245–362	0.72	0.64–0.81	<0.001
>362	0.60	0.48–0.74	<0.001

CI = confidence interval, ref = reference.

any systematic bias in the data quality by level of amputation or by geographic region.

Our study did not examine mobility or quality of life for Veterans with amputation; thus, we are unable to draw conclusions about the effect of prosthetic prescription on Veteran outcomes. Prior to prosthetic receipt, patients typically participate in preprosthetic rehabilitation to help manage their residual limb and improve range of motion, strength,

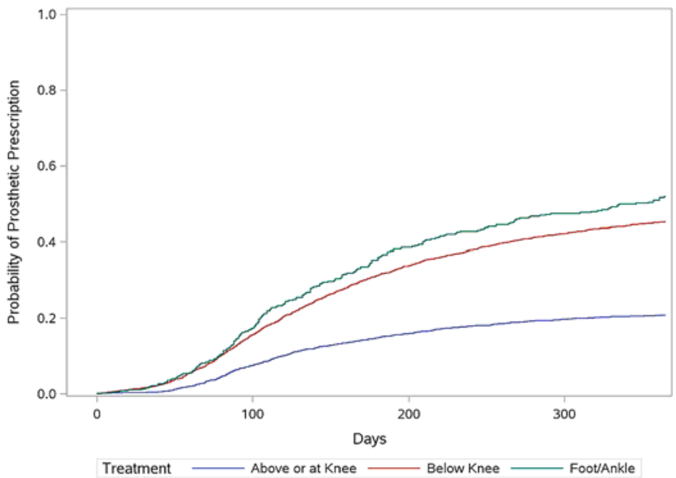

Figure 1.
Kaplan-Meier curve showing probability of prosthetic prescription by amputation level.

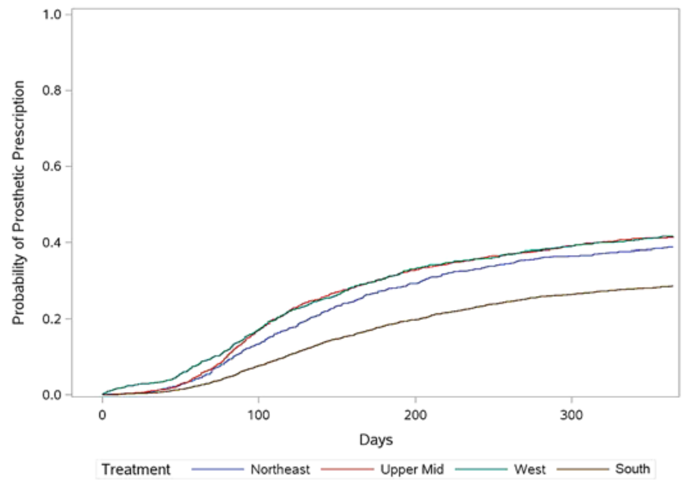

Figure 2.
Kaplan-Meier curve showing probability of prosthetic prescription by geographic region. Mid = Midwest.

balance, and overall mobility and independence in daily activities. Prescription and receipt of a lower-limb prosthesis is a single step in prosthetic rehabilitation. Successful prosthetic rehabilitation extends beyond prescription of the device. It incorporates a range of physical and functional interventions for prosthetic training to meet the patients' functional goals. Patients with amputation typically have balance and mobility problems and need therapy to learn to ambulate with their prosthesis.

CONCLUSIONS

We found geographic variation in the rate of prosthetic prescription for people with lower-limb amputation in the VA. Patients from the South were less likely to receive a prosthesis than patients from other areas of the country, and patients in the West and Northeast were most likely to receive one. These results are from models that control for important patient characteristics such as age, comorbidities, and living location prior to amputation. We also found that patients with ankle amputation were most likely to receive a prosthesis while those with TF amputation were least likely to receive one. These findings are consistent with prior research on receipt of other types of rehabilitation services after major amputation of a lower limb and suggest room for improvement in service delivery.

ACKNOWLEDGMENTS

Author Contributions:
Study concept and design: L. Resnik, M. Borgia.
Analysis and interpretation of data: L. Resnik, M. Borgia.
Drafting of manuscript: L. Resnik, M. Borgia.
Critical revision of manuscript for important intellectual content: L. Resnik, M. Borgia.
Financial Disclosures: The authors have declared that no competing interests exist.
Funding/Support: This material was based on work supported by the VA Rehabilitation Research and Development Service (grant A9264-S).
Institutional Review: The study was approved by the institutional review board of the Providence VA Medical Center.

REFERENCES

1. Millstein S, Bain D, Hunter GA. A review of employment patterns of industrial amputees—factors influencing rehabilitation. Prosthet Orthot Int. 1985;9(2):69–78. [PMID:4047922]
2. Sheikh K. Return to work following limb injuries. J Soc Occup Med. 1985;35(4):114–17. [PMID:4079344] http://dx.doi.org/10.1093/occmed/35.4.114
3. Millstein SG, Heger H, Hunter GA. Prosthetic use in adult upper limb amputees: A comparison of the body powered and electrically powered prostheses. Prosthet Orthot Int. 1986;10(1):27–34. [PMID:3725563]

4. Amputee Coalition of America. The economic benefits of prosthetic coverage [Internet]. Washington (DC): Amputee Coalition of America; 2006 Nov 16. Available from: http://www.hangerclinic.com/new-patient/Documents/economic-benefits-prosthetic-coverage.pdf
5. Biddiss E, Chau T. The roles of predisposing characteristics, established need, and enabling resources on upper extremity prosthesis use and abandonment. Disabil Rehabil Assist Technol. 2007;2(2):71–84. [PMID:19263542] http://dx.doi.org/10.1080/17483100601138959
6. Department of Veterans Affairs, Department of Defense. VA/DoD clinical practice guideline for rehabilitation of lower limb amputation: Guideline summary [Internet]. Washington (DC): VA Employee Education System, Offices of Quality and Performance and Patient Care Services; 2008 Jan [cited 2011 Sep 27]. Available from: http://www.healthquality.va.gov/amputation/amp_sum_508.pdf
7. Veterans Health Administration. Furnishing prosthetic appliances and services. VHA Handbook 1173.2. Washington (DC): Department of Veterans Affairs; 2000.
8. U.S. Government Accountability Office. VA health care: Spending for and provisions of prosthetic items. GAO-10-935. 2010.
9. Fletcher DD, Andrews KL, Butters MA, Jacobsen SJ, Rowland CM, Hallett JW Jr. Rehabilitation of the geriatric vascular amputee patient: A population-based study. Arch Phys Med Rehabil. 2001;82(6):776–79. [PMID:11387582] http://dx.doi.org/10.1053/apmr.2001.21856
10. Webster JB, Hakimi KN, Williams RM, Turner AP, Norvell DC, Czerniecki JM. Prosthetic fitting, use, and satisfaction following lower-limb amputation: A prospective study. J Rehabil Res Dev. 2012;49(10):1493–1504. [PMID:23516053] http://dx.doi.org/10.1682/JRRD.2012.01.0001
11. Nehler MR, Coll JR, Hiatt WR, Regensteiner JG, Schnickel GT, Klenke WA, Strecker PK, Anderson MW, Jones DN, Whitehill TA, Moskowitz S, Krupski WC. Functional outcome in a contemporary series of major lower extremity amputations. J Vasc Surg. 2003;38(1):7–14. [PMID:12844082] http://dx.doi.org/10.1016/S0741-5214(03)00092-2
12. Toursarkissian B, Shireman PK, Harrison A, D'Ayala M, Schoolfield J, Sykes MT. Major lower-extremity amputation: Contemporary experience in a single Veterans Affairs institution. Am Surg. 2002;68(7):606–10. [PMID:12132742]
13. Taylor SM, Kalbaugh CA, Blackhurst DW, Hamontree SE, Cull DL, Messich HS, Robertson RT, Langan EM 3rd, York JW, Carsten CG 3rd, Snyder BA, Jackson MR, Youkey JR. Preoperative clinical factors predict postoperative functional outcomes after major lower limb amputation: An analysis of 553 consecutive patients. J Vasc Surg. 2005;42(2):227–35. [PMID:16102618] http://dx.doi.org/10.1016/j.jvs.2005.04.015
14. Beekman CE, Axtell LA. Prosthetic use in elderly patients with dysvascular above-knee and through-knee amputations. Phys Ther. 1987;67(10):1510–16. [PMID:3659135]
15. Johannesson A, Larsson GU, Ramstrand N, Lauge-Pedersen H, Wagner P, Atroshi I. Outcomes of a standardized surgical and rehabilitation program in transtibial amputation for peripheral vascular disease: A prospective cohort study. Am J Phys Med Rehabil. 2010;89(4):293–303. [PMID:20134308] http://dx.doi.org/10.1097/PHM.0b013e3181cf1bee
16. Remes L, Isoaho R, Vahlberg T, Viitanen M, Rautava P. Predictors for institutionalization and prosthetic ambulation after major lower extremity amputation during an eight-year follow-up. Aging Clin Exp Res. 2009;21(2):129–35. [PMID:19448384] http://dx.doi.org/10.1007/BF03325220
17. Pernot HF, Winnubst GM, Cluitmans JJ, De Witte LP. Amputees in Limburg: Incidence, morbidity and mortality, prosthetic supply, care utilisation and functional level after one year. Prosthet Orthot Int. 2000;24(2):90–96. [PMID:11061195] http://dx.doi.org/10.1080/03093640008726531
18. Hermodsson Y, Ekdahl C, Persson BM. Outcome after trans-tibial amputation for vascular disease. A follow-up after eight years. Scand J Caring Sci. 1998;12(2):73–80. [PMID:9801627]
19. Campbell WB, Ridler BM. Predicting the use of prostheses by vascular amputees. Eur J Vasc Endovasc Surg. 1996;12(3):342–45. [PMID:8896478] http://dx.doi.org/10.1016/S1078-5884(96)80254-1
20. Jensen JS, Mandrup-Poulsen T, Krasnik M. Prosthetic fitting in lower limb amputees. Acta Orthop Scand. 1983;54(1):101–3. [PMID:6829273] http://dx.doi.org/10.3109/17453678308992877
21. Schoppen T, Boonstra A, Groothoff JW, de Vries J, Göeken LN, Eisma WH. Physical, mental, and social predictors of functional outcome in unilateral lower-limb amputees. Arch Phys Med Rehabil. 2003;84(6):803–11. [PMID:12808530] http://dx.doi.org/10.1016/S0003-9993(02)04952-3
22. Pohjolainen T, Alaranta H, Wikström J. Primary survival and prosthetic fitting of lower limb amputees. Prosthet Orthot Int. 1989;13(2):63–69. [PMID:2780262]
23. Reiber GE, McFarland LV, Hubbard S, Maynard C, Blough DK, Gambel JM, Smith DG. Servicemembers and veterans with major traumatic limb loss from Vietnam war and OIF/OEF conflicts: Survey methods, participants, and summary findings. J Rehabil Res Dev. 2010;47(4):275–97. [PMID:20803399] http://dx.doi.org/10.1682/JRRD.2010.01.0009

24. Etter K, Borgia M, Resnik L. Prescription and repair rates of prosthetic limbs in the VA healthcare system: Implications for national prosthetic parity. Disabil Rehabil Assist Technol. 2015;10(6):493–500. [PMID:24852068] http://dx.doi.org/10.3109/17483107.2014.921246
25. Lilja M, Objerg T. International forum: Proper time for permanent prosthetic fitting. J Prosthet Orthot. 1997;9(2):90–95. http://dx.doi.org/10.1097/00008526-199700920-00009
26. Resnik LJ, Borgia ML. Factors associated with utilization of preoperative and postoperative rehabilitation services by patients with amputation in the VA system: An observational study. Phys Ther. 2013;93(9):1197–1210. [PMID:23641029] http://dx.doi.org/10.2522/ptj.20120415
27. Zhou J, Bates BE, Kurichi JE, Kwong PL, Xie D, Stineman MG. Factors influencing receipt of outpatient rehabilitation services among veterans following lower extremity amputation. Arch Phys Med Rehabil. 2011;92(9):1455–61. [PMID:21878217] http://dx.doi.org/10.1016/j.apmr.2011.03.029
28. Health Services Research and Development Service. Data quality alerts: Information for applicants and reviewers [Internet]. Washington (DC): VA Information Resource Center; 2007 Jun [cited 2015 Aug 12]. Available from: http://www.hsrd.research.va.gov/funding/HSRD-Data-Quality-Alert-0907.pdf
29. Stroupe KT, Tarlov E, Zhang Q, Haywood T, Owens A, Hynes DM. Use of Medicare and DOD data for improving VA race data quality. J Rehabil Res Dev. 2010;47(8):781–95. [PMID: 21110252]
30. Healthcare Cost and Utilization Project. Comorbidity software, version 3.7 [Internet]. Rockville (MD): Agency for Healthcare Research and Quality; 2011 Oct 28 [cited 2011 Nov 15; updated 2015 Mar 6]. Available from: http://www.hcup-us.ahrq.gov/toolssoftware/comorbidity/comorbidity.jsp
31. Hedrick B, Pape TL, Heinemann AW, Ruddell JL, Reis J. Employment issues and assistive technology use for persons with spinal cord injury. J Rehabil Res Dev. 2006;43(2):185–98. [PMID:16847785] http://dx.doi.org/10.1682/JRRD.2005.03.0062
32. Pollard J, Hamilton GA, Rush SM, Ford LA. Mortality and morbidity after transmetatarsal amputation: Retrospective review of 101 cases. J Foot Ankle Surg. 2006;45(2):91–97. [PMID:16513503] http://dx.doi.org/10.1053/j.jfas.2005.12.011
33. Stone PA, Flaherty SK, Aburahma AF, Hass SM, Jackson JM, Hayes JD, Hofeldt MJ, Hager CS, Elmore MS. Factors affecting perioperative mortality and wound-related complications following major lower extremity amputations. Ann Vasc Surg. 2006;20(2):209–16. [PMID:16586027] http://dx.doi.org/10.1007/s10016-006-9009-z
34. Dillingham TR, Pezzin LE, Shore AD. Reamputation, mortality, and health care costs among persons with dysvascular lower-limb amputations. Arch Phys Med Rehabil. 2005;86(3):480–86. [PMID:15759232] http://dx.doi.org/10.1016/j.apmr.2004.06.072

Submitted for publication September 15, 2014. Accepted in revised form April 23, 2015.

This article and any supplementary material should be cited as follows:
Resnik L, Borgia M. Predicting prosthetic prescription after major lower-limb amputation. J Rehabil Res Dev. 2015;52(6):641–52.
http://dx.doi.org/10.1682/JRRD.2014.09.0216