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Medical utilization and cost outcomes for poststroke veterans who receive assistive technology devices from the Veterans Health Administration

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Abstract—The study objectives were to (1) advance understanding of the relationship between provision of assistive technology devices (ATDs) and healthcare consumption and outcomes in a system that does not limit provision of ATDs to in-home use and (2) determine how the provision of ATDs relates to inpatient/outpatient utilization and costs of services for veterans 12 months poststroke when controlling for case-mix. This was a retrospective study using Department of Veterans Affairs administrative/workload databases to identify 12,046 veterans with stroke during fiscal years 2001 and 2002. Measures were functional gain, inpatient days, outpatient visits, and inpatient and outpatient costs during the first year poststroke. Motor gain for veterans receiving ATDs was higher than for veterans not receiving ATDs (20 vs 9 Functional Independence Measure points, $p < 0.001$). Provision of a low-end manual wheelchair was associated with increased inpatient days and costs (both $p < 0.001$). Provision of a power wheelchair was associated with increased inpatient ($p = 0.03$) and outpatient costs ($p < 0.001$). Provision of a scooter was associated with increased outpatient visits and outpatient costs (both $p < 0.001$). Scooters, walking aids, and power wheelchairs were associated with increased outpatient visits, perhaps functioning as outpatient/community enablers.

Key words: activities of daily living, assistive technology, cost, disability, healthcare utilization, rehabilitation, self-care, stroke, veterans, wheelchair.

INTRODUCTION

Adults ≥65 years of age and people with physical disabilities are eligible for Medicare coverage of mobility

Abbreviations: ADL = activities of daily living, AFO = ankle-foot orthosis, ATD = assistive technology device, CMS = Centers for Medicare and Medicaid Services, FIM = Functional Independence Measure, FRG = Function-Related Group, FY = fiscal year, IADL = instrumental ADL, KFO = knee-foot orthosis, NPPD = National Prosthetics Patient Database, VA = Department of Veterans Affairs.

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devices, such as wheelchairs, walkers, and scooters, for use in their homes. However, they are not eligible for coverage of mobility devices that are solely for mobility outside their homes [1]. In 2005, the Centers for Medicare and Medicaid Services (CMS) determined that mobility assistive equipment is reasonable and necessary for beneficiaries who have limitations in activities of daily living (ADL), e.g., toileting, feeding, dressing, grooming, and/or bathing [2]. Instrumental ADL (IADL) were excluded from coverage because they are not limited to functions in the home. This CMS determination conflicts with legislative actions that mandate individuals with disabilities be provided with the necessary supports to live as independently as possible in their communities [1]. Even though increased use of assistive technology devices (ATDs) has been cited as one of the reasons for decreasing disability [3–4] and has positively affected health-related costs by reducing falls and, subsequently, hospital admissions and institutional care [4–11], fewer than 50 percent of older adults with chronic disability and fewer than 25 percent of individuals with recent disabilities received ATDs [12]. Further, only 6 percent of community-dwelling Medicare beneficiaries received any ATDs from Medicare [13].

In contrast to the Medicare system, the Department of Veterans Affairs (VA) does not restrict provision of ATDs to veterans for use only in the home, thus offering an opportunity for us to examine the relationship between ATD provision and community outcomes. During VA fiscal year (FY) 2001, the VA National Prosthetics Patient Database (NPPD) listed 3.8 million devices and/or device repairs at a cost of $486 million. The objective of our study was to advance understanding of the relationship between provision of ATDs and healthcare consumption and outcomes in a system that does not limit provision of ADL and mobility-related ATDs to in-home use. Our research question was "Controlling for case-mix, how does the provision of ATDs relate to inpatient and outpatient utilization and costs of services for veterans 12 months poststroke?"

"Each year, approximately 795,000 people experience a new or recurrent stroke. Approximately 610,000 of these are first attacks and 185,000 are recurrent attacks. Mortality data from 2006 indicate that stroke accounted for approximately 1 of every 18 deaths in the United States. On average, every 40 seconds, someone in the United States has a stroke" [14]. As the population ages, the social and economic burden of stroke is expected to increase [15]. An estimated 15,000 veterans are hospitalized in the VA for a new stroke each year [16]. Stroke and related diseases consume about 5 percent of VA resources [17]. In Canada, 43 percent of individuals 1-month poststroke were using a mobility-related ATD. Similarly, 40 percent of our poststroke veteran cohort received an ATD [18].

We are developing our methods to address equitable access to ATDs and services within the poststroke cohort for two reasons. First, veterans poststroke receive a high percentage of the ATDs provided by the VA [19]; i.e., stroke was the second most frequent primary diagnosis of veterans who received wheeled mobility devices, second only to chronic obstructive pulmonary disease/congestive heart failure. Second, stroke requires the most complex, challenging research design because of the recovery curve [20–21] and changing ATD needs. We began with a more challenging design and will apply this design to more static conditions (e.g., spinal cord injury) and progressive conditions (e.g., multiple sclerosis or polymyositis), in which individuals have the opportunity to consider (not necessarily accept) options.

DATA PREPARATION AND ANALYSES

An International Classification of Diseases-9th Revision code search of two national VA databases, the Functional Status Outcomes Database and the Medical SAS data sets [22], was used to identify 6,675 unique veterans who were provided VA care for stroke during FY01 and 6,689 unique veterans during FY02. Specific details have been previously published [18]. After data cleaning, the final study cohort included 12,046 unique veterans.

Data on veteran function, from Functional Independence Measure (FIM) scores [23], were acquired from the Functional Status Outcomes Database. FIM scores were only available for 5,519 (46%) of veterans in our cohort because the VA clinical directive mandating FIM assessment for veterans poststroke was only implemented in FY01. Inpatient and outpatient utilization and diagnoses codes for comorbidity measurement were obtained from the Medical SAS data sets. Cost data for FY01 to FY03 were obtained from VA Decision Support System Medical SAS cost extracts for inpatient, outpatient pharmacy, and outpatient nonpharmacy files for the first occurring stroke event and 12 months of follow-up.

ATD data were acquired from the NPPD and were limited to devices prescribed within 1 year of the index stroke admission in the following categories: (1) standard (low-end) manual wheelchairs; (2) lightweight and hemi rehabilitation (mid-range) manual wheelchairs; (3) ultralight manual (high-end) wheelchairs; (4) power wheelchairs; (5) power scooters; (6) ankle-foot orthoses (AFOs)/knee-foot orthoses (KFOs); and (7) walkers, crutches, and canes.

Bivariate (*t*-test) and multivariate (analysis of covariance) analyses were performed. Multivariate analyses were limited to the subset of the study cohort ≥65 years at the index stroke admission. The independent variable was provision of ATDs. Outcome variables were inpatient days and outpatient visits and costs of VA services poststroke. Because the cost data were skewed to the right, the natural log of each cost data value was used. Covariates for case-mix adjustment included age at index stroke; death during the 1-year follow-up period after the index stroke admission; sex, if the admission source was from a nursing home; marital status; hemorrhagic stroke; dysphasia; mechanical ventilation; treatment in a specialty rehabilitation unit; severity of disability; and comorbidity. The FIM Function-Related Groups (FRGs) system was used to control for severity of disability [24–27]. FRGs were based on the index stroke admission FIM score acquired from the Functional Status Outcomes Database. Of veterans 65 years or older, 5,474 had FIM scores. A challenge in ATD research is that individuals usually receive more than one ATD. To isolate and characterize associations with device prescriptions, we created a variable for each of our eight ATD categories. We assigned veterans who received only one ATD to the appropriate category. We created a ninth ATD variable for veterans who received more than one device. Data for other covariates were acquired from the Medical SAS data sets. The Elixhauser Index was used to measure comorbidity [22].

RESULTS

Of our population-based cohort of 12,046 unique veterans [18,28] with an index stroke during FY01 to FY02, 60 percent (n = 7,204) received ATDs. The population was typically male (98%). The mean age was 69 years for veterans who received ATDs and 68 years for veterans who did not receive ATDs. Of the cohort, 49 percent was married; 51 percent of veterans who received ATDs and 46 percent of veterans who did not receive ATDs were married. Hispanics and African Americans tended proportionally to receive devices at a slightly higher rate than whites. Patients with more severe disability (FRG1) tended to receive devices more often (13% for FRG1 vs 4%–8% for all other FRGs).

Table 1 presents the results of the bivariate analyses comparing veterans who did and did not receive ATDs. The admission FIM Motor score and the FIM gain (discharge – admission) were significantly different between the two groups. The functional gain (Motor) for veterans who received ATDs was much higher than for veterans who did not receive ATDs (19.7 FIM Motor points vs 9.4 FIM Motor points, $p < 0.001$). For veterans who did not receive ATDs, 15 percent died as a result of the index stroke and 21 percent died during the 12-month follow-up period. The index length of stay, number of inpatient days and outpatient visits during the 12-month follow-up period, and 12-month follow-up costs were higher for veterans who received ATDs. Veterans who died during the acute hospitalization for their index stroke were omitted from further analyses.

Table 2 presents the beta coefficients and *p*-values for the multivariate analyses. First, the covariate data are presented: demographic and severity of disability (FRG) [27] variables. Younger age was, for example, significantly associated with inpatient and outpatient days and costs. Index stroke admission from a skilled nursing facility was positively associated with increased inpatient and outpatient days. All levels of severity of disability (FRG) were significantly associated with a larger number of inpatient days and greater cost when compared with the referent, FRG9, the least disabled group. The highest number of inpatient days was associated with severe motor disability and being over the age of 74 with relatively high cognitive function (FRG3). The next highest number of inpatient days was associated with severe motor disability and age 16 to 74 (FRG1) followed by severe motor disability over the age of 74 with relatively low cognitive function (FRG2). FRG2 was associated with fewer outpatient visits while FRG7 (mild–moderately impaired motor function and relatively low cognitive function) was associated with increased outpatient visits.

Predictor variable data (ATD categories) are also presented in **Table 2**. Provision of a standard manual wheelchair; a rehabilitation manual wheelchair; a walker, cane, or crutch; or multiple ATDs was significantly associated

Table 1.
Bivariate comparisons of function, discharge location, length of stay, utilization, and costs for veterans who did or did not receive assistive technology devices.

Variable	Did Not Receive Device (n = 4,842)	Received Device (n = 7,204)	p-Value
FIM Motor Score			
Admission*	53.2	46.5	<0.001
Discharge*	62.2	63.6	0.097
FIM Gain	9.4	19.7	<0.001
Discharge Status (%)			
Died (index stroke)	14.6	3.3	<0.001
Community	70.8	74.5	
Nursing Home	10.6	17.6	
Other	18.7	7.9	
Index Length of Stay (d)	10.9	18.3	<0.001
Died During 12 Mo Follow-Up Period (%)	21.0	7.3	<0.001
Total Inpatient Days: 12 Mo Follow-Up (d)	21.1	44.1	<0.001
Total Outpatient Visits: 12 Mo Follow-Up	15.9	23.1	<0.001
Total VA Costs ($)	26,170	46,550	<0.001

*FIM scores only available for 1,425 patients who did not receive and 3,871 patients who did receive devices.
FIM = Functional Independence Measure, VA = Department of Veterans Affairs.

with more inpatient days. Provision of a scooter; a walker, cane, or crutch; or multiple ATDs was significantly associated with more outpatient visits. Provision of a standard manual wheelchair; a rehabilitation manual wheelchair; a power wheelchair; a walker, cane, or crutch; or multiple ATDs was significantly associated with inpatient costs over the 12-month poststroke period. Provision of a power wheelchair; a scooter; a walker, cane, or crutch; or multiple ATDs was significantly associated with increased outpatient costs.

A second way of interpreting the multivariate data is by device rather than by utilization outcome. Lower-end manual wheelchairs had significant associations only with inpatient utilization (costs and days), power wheelchairs only with higher costs (inpatient and outpatient), and scooters only with outpatient utilization (visits and costs).

DISCUSSION

This study identified 12,046 veterans who experienced a stroke in FY01 or FY02 and examined bivariate relationships between ATD provision and functional gain, inpatient and outpatient care, and costs. We then created five models with inpatients days, inpatient dollars, outpatient visits, outpatient dollars, and discharge status as outcome variables. We found that provision of mobility ATDs is associated with motor gain and that provision of a scooter is associated with more outpatient visits, when controlling for both disability and comorbidity.

Length of Stay

Length of stay, because of its effect on cost, has been the focus of much research [29] but not with regards to the effects of ATDs. The only other known study to investigate length of stay in the context of ATD provision was Garber et al., who looked at "rehabilitation" length of stay for poststroke veteran wheelchair users [30]. We examined length of stay in the acute care, not rehabilitation, setting, so it is not surprising that our acute care length of stay at 11 days for veterans who received ATD(s) and 18 days for veterans who did not receive ATD(s) was much shorter than that of Garber et al., who reported length of stay for wheelchair recipients of 73 days [30]. The reasons for these differences may be the inclusion of rehabilitation length of stay, which is frequently longer than acute length of stay [29] and that the Garber et al. [30] data were collected earlier (1989–99) than our data. Rehabilitation lengths of stay were typically longer during the period when Garber et al. collected their data [31–32].

Our acute care length of stay results for veterans with an acute stroke were similar to other studies. For example,

Table 2.
Ordinary least squares regression results (coefficients) for demographic, patient function (covariates), and VA device prescription (predictor variable) for five dependent variables: inpatient days, outpatient visits, inpatient and outpatient costs, and discharge to community (logistic regression). Only statistically significant beta coefficients (*p*-value) at alpha < 0.05 are shown.

Variable	Outcome Variable			
	Inpatient Days (*n* = 5,474)	Inpatient Costs ($) (*n* = 5,474)	Outpatient Visits (*n* = 5,054)	Outpatient Costs ($) (*n* = 5,154)
Covariates				
Age	–0.3 (0.003)	–0.004 (0.002)	–0.2 (<0.001)	–0.006 (<0.001)
Died	–8.8 (0.005)	NS	–11.9 (<0.001)	–1.2 (<0.001)
Male	NS	NS	–6.2 (<0.001)	–0.3 (0.01)
Nursing Home PTA	18.8 (0.006)	NS	12.3 (<0.001)	NS
Married	–3.5 (0.03)	–0.1 (<0.001)	2.6 (<0.001)	0.1 (0.007)
Hemorrhagic Stroke	NS	NS	NS	NS
Dysphagia	NS	0.1 (0.01)	NS	NS
On Ventilator	NS	0.6 (<0.001)	NS	0.4 (0.002)
Treated in Acute Rehabilitation	7.2 (<0.001)	0.4 (<0.001)	2.8 (<0.001)	0.1 (0.01)
FRG1	40.8 (<0.001)	1.2 (<0.001)	NS	–0.2 (0.002)
FRG2	38.8 (<0.001)	1.1 (<0.001)	–3.7 (0.02)	–0.4 (<0.001)
FRG3	45.5 (<0.001)	1.2 (<0.001)	NS	NS
FRG4	28.4 (<0.001)	1.0 (<0.001)	NS	NS
FRG5	23.7 (<0.001)	0.8 (<0.001)	NS	NS
FRG6	13.4 (<0.001)	0.6 (<0.001)	NS	NS
FRG7	11.6 (<0.001)	0.5 (<0.001)	3.7 (0.002)	NS
FRG8	8.6 (0.02)	0.3 (<0.001)	NS	NS
Elixhauser Index Number of Significant Variables	3	2	1	1
Predictor Variables				
One VA AFO/KFO Only	16.0 (0.03)	0.2 (0.04)	NS	NS
One VA Std Manual W/C Only	16.3 (<0.001)	0.3 (<0.001)	NS	NS
One VA High-End Manual W/C Only	NS	NS	NS	1.0 (0.006)
One VA Rehabilitation Manual W/C Only	24.5 (<0.001)	0.4 (<0.001)	NS	NS
One VA Power W/C Only	NS	0.4 (0.03)	NS	1.0 (<0.001)
One VA Scooter Only	NS	NS	17.9 (<0.001)	1.0 (<0.001)
One VA Walker, Crutch, or Cane Only	4.3 (0.03)	0.2 (<0.001)	4.1 (<0.001)	0.3 (<0.001)
VA Multidevice Exclusion AFO/KFO	14.5 (<0.001)	0.4 (<0.001)	7.3 (<0.001)	0.5 (<0.001)
Adjusted R^2	0.11	0.30	0.10	0.12

AFO = ankle-foot orthosis, FRG = Function-Related Group, KFO = knee-foot orthosis, NS = not significant, PTA = prior to admission, Std = standard, VA = Department of Veterans Affairs, W/C = wheelchair.

Jia et al. found the mean length of acute stay for veterans with stroke was 20 days [33]. Some studies of acute hospitalization for stroke report lengths of stay ranging from 4 to 8 days (nonveteran facilities) [34–35]; however, Hoh et al. reported a mean length of stay of 19 to 21 days for ruptured aneurysms compared with 4 to 9 days for unruptured aneurysms (also nonveteran facilities) [36]. Investigators have failed to find a significant difference in length of stay for individuals with stroke in VA versus Medicare facilities [33,37].

It is well known that physical function is a strong predictor of acute length of stay [29,38]. Our bivariate analyses showed that veterans who received ATDs had a longer length of stay and more severe disability at admission than veterans who did not receive ATDs. Therefore, our multivariate models, which controlled for severity of disability, still showed that low- and moderate-end manual wheelchairs, walkers, AFOs/KFOs, and multiple ATDs were associated with longer inpatient stay and admission to inpatient rehabilitation. Similarly, we found that outpatient visits after an acute stroke were related to

ATD provision, even after controlling for functional skills on admission. Specifically, provision of a scooter or walking device was associated with outpatient visits, indicating these devices may enable better outpatient healthcare.

Functional Gain

More revealing than function at admission was functional gain during the hospital episode of care. In our study, veterans who received ATDs had a significantly higher motor gain (20 out of 91 possible FIM Motor points, acute length of stay 18 days) than veterans who did not receive ATDs (9 out of 91 possible FIM Motor points, acute length of stay 11 days). Mountain et al. found a similar trend in admission to discharge gain in the "rehabilitation" environment, with wheelchair users experiencing a mean total FIM gain of 24 points (126 possible points, mean rehabilitation length of stay of 41 days) compared with a gain of 16 points (126 possible for points, mean rehabilitation length of stay of 27 days) for nonwheelchair users [39]. Granger et al. and Ottenbacher et al. also looked at functional gain in a 2001 national stroke cohort but did not consider provision of ATDs in their analyses [31–32]. While findings of functional gain by Granger et al. are comparable to ours (21 FIM Motor points during inpatient "rehabilitation" with a mean length of stay of 20 days compared with our mean gain of 20 FIM Motor points during "acute" inpatient stay with a mean length of stay of 18 days) [31], Granger et al. did not examine the effect of ATD provision. Ottenbacher et al. performed a similar analysis using total FIM score [32]; because our study used only FIM Motor scores, functional gain cannot be compared. The observed increase in functional gain in our study may be attributed to the ATDs and/or increased length of stay in persons receiving ATDs and the natural course of stroke recovery; future studies should tease out the causal mechanisms underlying the important relationship between ATD provision and better functional outcomes.

Discharge Status

Our study failed to find an overall significant association between provision of ATD(s) and discharge status. That is, the pattern of provision of ATDs for veterans discharged from acute to home, community, or rehabilitation was similar to the provision of ATDs for veterans discharged to a nursing home or institution. There was one exception: a higher percentage of veterans who received a walker, cane, or crutch were discharged to the community. Other studies have shown that functional status, social situation prior to stroke, and level of cognition predict discharge status [40–42]; no studies of discharge status were found that included provision of ATDs.

Limitations

A limitation to this study was that administrative data were used. Administrative data are the by-product of running a healthcare system [43]. A disadvantage of using administrative data is that the data may be coded inconsistently or erroneously and may be incomplete [44]. There are, however, advantages of using administrative data: administrative data include a large number of people, track service utilization, and are already in existence [43]. In previous studies, we have shown that once data cleaning, considered routine in large data studies, is performed, NPPD data are valid for identifying devices provided to veterans [18–19,28,45–47]. Another limitation of this study is that the ATDs provided may not have been related to stroke; the ATD(s) could have been prescribed for another disease or injury. Finally, this is a cohort study and aspects of the study are cross-sectional in nature. We cannot be sure within this database when ATDs were provided in relationship to specific improvements in function or how they relate to clinical decision-making. Thus, we cannot be sure of the causal relationship between ATD provision and the various outcomes.

Despite the study limitations, we think our findings have important policy implications for the VA and the CMS. Our findings are pertinent to Medicare policy in so far as Medicare coverage for mobility devices, such as wheelchairs and walkers, is limited to persons who will use the device in their homes. Unlike those covered by the VA, these individuals cannot get coverage for mobility devices needed for IADL because these activities are not limited to mobility functions "in the home" [1–2]. We know that the use of ATDs is associated with decreased disability [3–4], which reduces falls and subsequent hospital admissions/institutional care [4–11] and, thus, healthcare costs. It makes sense then, in the context of healthcare reform (reduction in emergent care and rehospitalization [48–49], implementation of the medical home model [50]) that the savings be reinvested in expanding the provision of ATDs. Expansion of provision of ATDs to maintain independence, aging in place, and quality of life is in the best interest of elderly patients, who have the technology to age in place (Wi-Fi

exercise, robot vacuum cleaners), and society. Social isolation can lead to a number of major health problems (depression, substance abuse, etc.) and can greatly reduce quality of life and well-being [51]. Even the more expensive ATDs, e.g., custom power wheelchairs, are less costly than residential skilled nursing care.

CONCLUSIONS

Our findings show that provision of mobility ATDs to veterans by the VA predicts greater functional gain while in the hospital and, most notably, greater outpatient visits, when both disability and comorbidity were controlled for, indicating that these devices may enable better outpatient healthcare. However, the ATD recipients did have longer lengths of stay so future studies may want to focus on how to meet ATD care needs more efficiently.

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