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Walking speed predicts health status and hospital costs for frail elderly male veterans

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Abstract—This study evaluated the use of walking speed as an indicator of function and health status in acutely ill, hospitalized, older male veterans. Hospital inpatients in a Department of Veterans Affairs (VA) study of Geriatric Evaluation and Management (GEM) (*n* = 1,388, age 74.2 +/– 5.7, 98% male) were followed for 1 year. The results indicate that each 0.10 m/s reduction in baseline walking speed was associated with poorer health status (36-item short form [SF-36] beta = 4.5 [95% confidence interval (CI) 2.8 to 6.1]), poorer physical functioning (beta = 2.1 [6.9 to 14.8]), more disabilities (beta = 0.63 [0.53 to 0.73]), additional rehabilitation visits (2.0 [1.4 to 2.5]), increased medical-surgical visits (2.8 [1.9 to 3.7]), longer hospital stays (2.2 [1.4 to 2.9]), and higher costs ($1,334 [$869 to $1,798]). In addition, each 0.10 m/s/yr increase in walking speed resulted in improved health status (SF-36 beta = 8.4 [6.0 to 10.7]), improved physical function (beta = 2.9 [2.5 to 3.3]), fewer basic disabilities (0.30 [0.2 to 0.4]), fewer instrumental disabilities (0.7 [0.6 to 0.8]), fewer hospitalization days (2.3 [1.3 to 3.3]), and 1-year cost reductions of $1,188 [–$65 to $2,442]. Walking speed is useful for the functional assessment of acutely ill, hospitalized older adults. Measurement of walking speed over time may help predict those who will need and use more health-related services.

Key words: acute care, functional status, gait speed, geriatric evaluation and management, healthcare costs, health services use, health status, hospitalized older adults, physical function, walking ability.

INTRODUCTION

Geriatricians, healthcare epidemiologists, and physical therapists increasingly recommend walking speed (also referred to as "gait" speed) as a clinically important

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Abbreviations: ADL = activities of daily living, BADL = basic activities of daily living, CI = confidence interval, GEM = geriatric evaluation and management, IADL = instrumental activities of daily living, LOS = length of stay, PPT = Physical Performance Test, RA = research assistant, SAS = Statistical Analysis Software, SD = standard deviation, SF-36 = 36-item short form, VA = Department of Veterans Affairs.

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indicator for community-dwelling elderly adults [1]. Gait-speed assessment is pragmatic because it takes less than 5 minutes, can be completed by trained nonclinicians, uses inexpensive equipment, and is reliable over repeated measurements [2–3]. Recent research shows that gait speed predicts morbidity, nursing home placement, and survival among community-dwelling older adults [4–6]. As a performance-based measure of physical functioning, gait speed may be a good surrogate for more comprehensive and time-consuming assessments of health-related quality of life [7], and its use has been recommended as a vital sign for the outpatient assessment of older adults [8]. Gait speed alone is comparable with more extensive functional assessments for clinical screening as well as outcomes in clinical trials [1]; however, its utility in different clinical settings and populations is still being discussed [9–10]. Given the prevalence, cost, and consequences of acute hospitalization in older adults, the inpatient setting may be an important venue for assessing gait speed. To our knowledge, this research has not been conducted in an acute-care setting. This study examines the association between walking speed and hospitalization-related health services use and costs in a cohort of acutely ill, hospitalized, older male veterans. We evaluated gait speed's association with clinically relevant indicators at admission and also its (baseline and change over 12 months) association with hospital use of services, inpatient and 1-year costs of care, and 1-year change in quality of life and disability.

METHODS

Participants were enrolled in a Department of Veterans Affairs (VA) multicenter clinical trial on the effect of Geriatric Evaluation and Management (GEM) programs. Between August 1, 1995, and January 31, 1999, hospitalized older veterans were enrolled from 11 VA Medical Centers [11–12]. Methods, procedures, and results have been previously reported [13]. Data for the current study were from admission, discharge, and 12-month assessments [13]. Research assistants (RAs) at each center administered baseline screening and all on site performance assessments. Central RAs collected all follow-up data on health status and functional status via telephone. Healthcare use and costs were obtained from VA computerized records [13–14].

Patients and Study Group

English-speaking medical or surgical patients who were older than 65, who met study screening criteria for frailty, and who were likely to be hospitalized for at least 48 hours were eligible. The screening criteria for frailty included stroke, two or more falls, unplanned hospitalization (previous 3 months), prolonged bed rest (in the 2 weeks preceding admission), reported difficulty walking, incontinence, dependence with one or more of five basic activities of daily living (BADLs), malnutrition (serum albumin <3.5 g/dL or <80% of ideal body weight), diagnosis of dementia [15], or depression (preexisting or established at admission). Patients were designated as frail if the presence of two or more frailty indicators was confirmed. Those with a previous GEM hospitalization, current nursing home residence, participation in a clinical trial, severe dementia or disability, a terminal diagnosis, or inability to participate in follow-up were excluded. Eligible patients were randomized to inpatient GEM or usual care, followed by the corresponding outpatient service. For the present cohort study, treatment and control groups from the parent trial were combined and controlled for in analyses.

Demographics and Medical Comorbidity

Age, gender, race (black/black Hispanic, white/white Hispanic, or other), and education (year) were obtained. The Charlson Comorbidity Index [16], number of confirmed frailty indicators from screening procedures, and number of prescription medications were also recorded.

Performance-Based Assessments

Reuben's Physical Performance Test (PPT) was administered at admission, at discharge, and at 12-months postrandomization [17]. The PPT rates timed performance on seven physical function items: eating, writing, putting on a jacket, picking a penny up from the floor, turning, walking, and lifting a heavy book. Scores range from 0 to 28, and higher scores indicate better functioning. Walking times were obtained from the 50 ft walking trial of the PPT. Although the walking trial was scored categorically as part of the PPT, we retained the original walk times and converted them to a continuous gait velocity. In the PPT, individuals who cannot complete the walk test in 90 s are assigned the lowest categorical score; we adopted this approach for use with the continuous scores by assigning the slowest possible walking velocity (50 ft/90 s = 0.17 m/s) to these individuals. While all participants in this lowest category were objectively determined to walk no faster than 0.17 m/s, theoretically, they could have walked at any slower speed within the narrow, nonfunctional range from 0 to 0.17 m/s. Because the exact speed within this range was not recorded as part of the original PPT administration, we chose 0.17 m/s as a conservative estimate of initial walking ability in this slowest group (i.e., one that would not inflate potential improvements noted during the study). We used this speed in quantitative analysis to distinguish those with positive trajectories of gait speed (i.e., improvement) from those whose gait speed remained at or below 0.17 m/s. We created a second gait-speed variable from the most extreme assumptions about beginning walking speed—that all the slowest walkers were in fact nonambulatory and had an initial walking speed of 0 m/s—in order to assess the sensitivity of our results to the choice of this imputed speed for the slowest walkers. For this second gait-speed variable, every person who could not complete the test in 90 s was assigned an initial walking speed of 0 m/s.

A gait speed of approximately 1.2 m/s (the velocity typically used to establish crossing times at traffic intersections) is generally considered normal for adults [18–19]. In comparison, a previous study conducted with patients in a geriatric rehabilitation unit found that ~55 percent walked at admission speeds below 0.23 m/s and that a speed of ~0.15 m/s best discriminated between older adults requiring institutionalization and those who could be discharged to their homes or to a rest home [20].

Self-Reported Disability and Health Status

We used baseline, discharge, and 12-month assessments of the number of BADL and instrumental activities of daily living (IADL) disabilities [21–22]. The total number of disabilities was also recorded.

We used participant responses from the 36-item short form (SF-36) of the Medical Outcomes Study General Health Survey to assess general health status [23]. We present baseline and longitudinal associations with the total SF-36 summary score. However, past research with multidimensional summary scales suggests that individual subscale effects may also be relevant [24–25]. For this reason, we also evaluated associations with individual subscales of the SF-36 (physical function, physical role function, emotional role function, bodily pain, energy/fatigue, mental health, social function, and general health).

Healthcare Use and Costs

We used VA databases to obtain length of stay (LOS), in days, for the index hospitalization [13–14]. We also used the number of inpatient medical consultations (cardiology, dermatology, endocrinology, gastroenterology, geriatrics, hematology/oncology, infectious diseases, nephrology, neurology, pulmonary, and rheumatology), the number of surgical visits (cardiothoracic, general surgery, gynecology, neurosurgery, ophthalmology, oral-maxillofacial, orthopedics, otolaryngology, plastic surgery, urology, transplant surgery, and vascular), and the number of inpatient rehabilitation visits (physical, occupational, and speech therapy, and social work visits). Healthcare costs were recorded for the index hospitalization and total 1-year follow-up (including postdischarge care) [13–14].

Analysis

We performed the analysis with Statistical Analysis Software (SAS) (SAS Institute, Inc., Cary, North Carolina). The analysis included evaluation of univariate distributions and missing data. We used measures of central tendency to characterize continuous measures and frequencies to describe categorical variables. Because the purpose of this investigation was to determine whether gait speed is associated with important clinical indicators and hospital use, not to evaluate the effect of GEM treatment, data from the treatment arms of the underlying trial were combined and adjustment for treatment assignment was made in all analyses.

Baseline Associations with Gait Speed

We initially evaluated the concurrent validity of gait speed and clinical indicators of general health and well-being at baseline by correlating each baseline clinical indicator with baseline values of gait speed; we report these crude associations using Spearman's correlation coefficients (r_s). We further examined the concurrent associations between baseline gait speed and selected measures of health status and disability using multiple regression and adjusting for age, gender, race, education, number of prescription medications, and medical comorbidity (Charlson Index). Beta coefficients and 95 percent confidence intervals (CIs) are presented.

Prospective Associations with Gait Speed

We used the SAS MIXED procedure [26] to generate empirical Bayes estimates of gait-speed change, change in disability, and change in health status for every patient in the study. A longitudinal random-effects design allowed us to account for varying numbers of observations per person and for dependence of observations [27–28]. The hierarchical linear model is

$$Y_{it} = \beta_{0i} + \beta_{1i}(\chi_{it}) + \varepsilon_{it},$$
$$\beta_{1i} = \lambda_{10} + \lambda_{11}(Z_i) + \ldots \lambda_{1n}(Z_i) + \mu_{1i},$$
$$\beta_{0i} = \lambda_{00} + \lambda_{0i},$$

where Y_{it} describes gait speed for person i at time t and time (χ) was coded continuously and individual occasions are represented by the subscript t. The term β_{0i} represents the intercept, and β_{1i} the slope for the ith individual-level trajectory. The λ represents the fixed effects of covariates on the individual level slopes and intercepts, Z_i represents the fixed effects design matrix, ε_{it} is the within-person error term for the ith person at time t, and μ_{1i} denotes residual between-person error for the ith slope. Covariates included age, gender, race, education, treatment assignment, baseline comorbidity, and number of prescription medications.

For each model, the underlying residual error structure was evaluated and specified as compound symmetric. The primary statistical assumption of the longitudinal hierarchical linear model used is that the between-person residuals for the individual trajectories are approximately normally distributed, conditional on the fixed effects (e.g., $\beta_i \sim N[Z_i\lambda, \tau]$, where Z_i is the design matrix for person i and τ is the between-person variance) [28]. No assumptions are necessary regarding the normality of the gait-speed outcome distribution at single time points. Homoscedasticity of level 1 residuals across time points is assumed.

We regressed hospital use and costs and individual empirical Bayes estimates of health status and disability on (1) the distribution of baseline gait speed and (2) the empirical Bayes distribution of gait-speed change. Absolute effects and 95 percent CI per 0.10 m/s difference in baseline gait speed and per 0.10 m/s/yr change in gait speed over the 12-month period of the study were estimated. Previous work in the outpatient clinic has used a similarly coded metric of presentation when gait speed is used as a continuous variable in analysis [8,29]. We used methods previously recommended by the test developer (with the general U.S. population as a standard) to present estimates for the SF-36 measure of health status as standardized effects [30].

RESULTS

At baseline, PPT data were available for all 1,388 patients. Seventy-four percent of participants in the sample were objectively determined to walk at speeds below 0.17 m/s at baseline, a statistic that improved during the study (to 57% at discharge and 50% at 12-months post-discharge). The individuals who took longer than 90 s to complete the 50 ft walking test were assigned the baseline minimum walking speed of 0.17 m/s. Of these 1,013 subjects, 491 (48%) improved to a measurable walking speed at follow-up; 131 did so by hospital discharge and 360 did so by 12-months postdischarge. The remaining 522 (52%) had no improvement from this slowest value and were observed to have a flat trajectory for the individual estimate of change over time. Of the 522 nonimprovers, 356 (68%) were tested at all three measurements and were observed to remain stable; the remaining 166 (32%) remained stable over two measurements and then had a final missing observation (due to death for 165 people; 1 person was lost prior to follow-up). Fifteen of the individuals who were assigned a baseline score died before the second observation.

Table 1 gives demographic and health services use characteristics of the full baseline sample as well as univariate distributions of health-related indicators across the multiple observations of the study. After 12 months, 297 patients (21%) had died; only 1 person was lost prior to follow-up. On average, the sample was male and white and had less than a high school education **(Table 1)**. The number and proportion of participants with each of the frailty indicators is also shown in **Table 1**. Notably, with respect to mobility at admission, ~85 percent of the sample had one or more physical disabilities, ~10 percent had experienced a stroke in the previous 30 days, 88 percent reported use of equipment or personal assistance for mobility, and 18 percent reported prolonged bed rest in the previous 2 weeks.

The large number of individuals observed with dysfunctional walking speed at admission is consistent with data from other measures recorded at baseline. For example, 92.5 percent of those assigned the slowest walking speed at baseline reported "difficulty ambulating," 20 percent had experienced prolonged bed rest in the 2 weeks prior to admission, 87 percent reported difficulty walking one block, and 97 percent reported dependency with walking 1 mile. For those who walked faster than 0.17 m/s, the average walking speed at baseline was 0.5 m/s, which is

Table 1.

Univariate characteristics of sample (*n* = 1,388) at baseline and follow-up (mean ± standard deviation unless otherwise noted).

Characteristic	Baseline	Discharge	12 Months Postrandomization
Age	74 ± 6	—	—
Gender, No. (%)			
Male	1,355 (98)	—	—
Female	33 (2)	—	—
Race			
White	1,007	—	—
Black	367	—	—
Other	14	—	—
Education (yr)	10.3 ± 3.5	—	—
Charlson Comorbidity Score	2.6 ± 1.9	—	—
Frailty Score*	3.3 ± 1.2	—	—
≥1 ADL disability, No. (%)	1,183 (85)	—	—
Dementia	122 (9.0)	—	—
Incontinent	363 (26)	—	—
Stroke (past 30 d)	141 (10)	—	—
>1 Fall (past 3 mo)	294 (21)	—	—
Difficulty Walking	1,222 (88)	—	—
Malnourished	477 (34)	—	—
Depression	135 (10)	—	—
Unplanned Admission	430 (31)	—	—
Prolonged Bed Rest	244 (18)	—	—
Gait Velocity†			
Meters Per Second	0.50 ± 0.21	0.53 ± 0.24	0.63 ± 0.23
Meters Per Minute	30.0 ± 12.6	31.8 ± 14.4	37.8 ± 13.8
Completed Walking in ≤90 s, No. (%)	360 (26)	595 (43)	550 (50.3)
12 Mo Δ Gait Velocity (m/s)‡	0.12 ± 0.12	—	—
Reuben Physical Performance Test§	6.19 ± 4.7	8.8 ± 5.1	10.8 ± 5.8
SF-36 Total Score¶	293.1 ± 57.6	300.1 ± 54.5	325.9 ± 63.3
Physical Function	25.5 ± 10.5	24.2 ± 10.5	28.2 ± 12.7
Role Physical	32.0 ± 8.1	33.5 ± 7.7	41.1 ± 10.4
Role Emotional	43.0 ± 14.0	47.1 ± 11.4	49.7 ± 9.6
Bodily Pain	38.6 ± 13.5	44.0 ± 14.2	48.0 ± 13.4
Energy/Fatigue	39.5 ± 11.5	39.3 ± 11.6	41.6 ± 12.1
Mental Health	43.6 ± 13.7	43.2 ± 13.2	45.8 ± 12.9
Social Function	32.4 ± 11.7	31.4 ± 10.7	35.3 ± 10.3
General Health	38.7 ± 10.2	38.0 ± 11.0	36.3 ± 11.5
No. of Disabilities			
BADL Score	2.9 ± 2.0	1.7 ± 1.9	1.3 ± 1.8
IADL Score	2.7 ± 2.5	5.5 ± 2.7	4.7 ± 3.2
Total No.	5.6 ± 3.6	7.2 ± 4.2	6.0 ± 4.7

Table 1. (Continued)
Univariate characteristics of sample (n = 1,388) at baseline and follow-up (mean ± standard deviation unless otherwise noted).

Characteristic	Baseline	Discharge	12 Months Postrandomization
Health Services Use and Costs			
Median Length of Stay (d)	—	10.1	—
25th–75th Percentile	—	4–24	—
Median Costs of Care			
Hospitalization	—	$12,103	—
25th–75th Percentile	—	$2,833–$15,169	—
Total 1 Yr Costs of Care	—	$24,073	—
25th–75th Percentile	—	$12,329–$49,163	—
Median No. of Inpatient Rehabilitation Visits	—	5	—
25th–75th Percentile	—	1–13	—
No. of Inpatient Medical-Surgical Consultations	—	13	—
25th–75th Percentile	—	4–30	—
Median Outpatient Clinic Costs	—	$3,311	—
25th–75th Percentile	—	$1,275–$6,201	—

*Patients were determined to be frail if two or more of the following conditions were confirmed: stroke, two or more falls, unplanned hospitalization in previous 3 months, history of prolonged bed rest during 2 weeks preceding admission, reported difficulty walking (use of personal assistance or assistive device), incontinence, dependence with one or more of five BADLs (bathing, dressing, toileting, transferring, or eating), positive screening results for malnutrition (serum albumin <3.5 g/dL or <80% of ideal body weight), diagnosis of dementia based on the Clinical Dementia Rating scale, or diagnosis of depression.
†Mean ± standard deviation for individuals able to complete test in < 90 s.
‡Empirical Bayes estimate.
§Scores range from 0–28 with higher scores indicating better function.
¶Individual subscales are standardized to 1998 general U.S. population. Higher scores indicate better functioning. SF-36 total score was computed for each patient as a sum of individual standardized scale scores.
ADL = activities of daily living, BADL = basic ADL, IADL = instrumental ADL, SF-36 = 36-item short form.

far slower than that necessary for safe pedestrian crossings at traffic intersections (~1.0 to 1.2 m/s) [18–19]. Thus, dysfunctional gait is a major problem for acutely ill, hospitalized, older adults.

Subscales of the SF-36 **(Table 1)** are standardized to the 1998 general U.S. population mean and standard deviation (SD). Subscale scores of 50 and SDs of 10 represent average scores and variability for the general U.S. population of older adults [29]. **Table 1** shows that on average the health status scores of this frail, elderly hospitalized sample are below that of the corresponding community-dwelling U.S. population, as might be expected for an acutely ill group of older adults. **Table 1** also shows that on average both gait speed and total SF-36 scores improved during follow-up. BADL improved over the 12-month period of follow-up, while on average a worsening of IADL ability was noted.

Baseline Associations with Gait Speed

Correlations with gait speed at initial hospitalization were conducted with the full sample (n = 1,388), and were largest for the PPT (r_s = 0.64), number of BADL disabilities (r_s = –0.41), the physical function subscale of the SF-36 (r_s = 0.40), number of physical therapy inpatient rehabilitation visits (r_s = –0.34), and total number of disabilities (BADL + IADL r_s = –0.32). Correlations between gait speed and total number of inpatient rehabilitation visits, number of frailty items, LOS, and number of occupational therapy inpatient rehabilitation visits were somewhat lower (r_s = –0.23 to –0.29). Baseline correlations with all other indicators were less than 0.15 (age, race, education, comorbidity, all subscales of the SF-36, number of medical, surgical, speech, and social work inpatient consults). The magnitude and pattern of these associations did not differ substantially when the analysis

Table 2.
β coefficients and 95 % confidence intervals (CIs) representing average difference in baseline health and disability status, inpatient rehabilitation visits, medical-surgical visits, and inpatient costs per 0.10 m/s difference in gait speed at baseline (baseline regression analysis controlling for age, gender, race, education, number of medications, treatment assignment, and Charlson Comorbidity Index, n = 1,388).

Health Status Characteristic	Unit Difference* in Indicator per 0.10 m/s in Baseline Gait Speed (95% CI)
SF-36 Total Score	
Raw Units	10.8 (6.9 to 14.8)
Standardized Units	4.5 (2.8 to 6.1)
SF-36 Physical Function Subscale	
Raw Units	5.0 (4.3 to 5.6)
Standardized Units	2.1 (1.8 to 2.4)
No. of Disabilities	–0.63 (–0.73 to –0.53)
No. of Inpatient Rehabilitation Visits	–2.0 (–2.5 to –1.4)
No. of Inpatient Medical-Surgical Visits	–2.8 (–3.7 to –1.9)
Length of Stay (d)	–2.2 (–2.9 to –1.4)
Inpatient Costs	–$1,334 (–$1,798 to –$869)

*β coefficient and 95% CI per unit Δ in gait speed.
SF-36 = 36-item short form.

was restricted to the subsample of patients who walked faster than 0.17 m/s at baseline.

Table 2 shows coefficients and 95 percent CIs for the association between baseline walking speed and selected health status and health services use indicators, adjusted for age, gender, race, number of prescription medications, comorbidity, and underlying GEM trial treatment arm. This table shows the magnitude by which two people in this sample are predicted to differ in their baseline clinical and health status for each 0.10 m/s difference in their walking speed at hospitalization. As previously observed in community and outpatient samples, hospitalized individuals who walk more slowly have poorer health status as measured by the SF-36 (both total score and physical functioning subscale) and also have a greater number of self-reported disabilities. Each 0.10 m/s positive difference in walking speed between people at admission corresponded to approximately 4.5 points higher on the standardized SF-36, 2.1 points higher on the standardized Physical Functioning subscale of the SF-36, and ~0.63 fewer total activities of daily living (ADL) disabilities.

Prospective Associations with Gait Speed

With respect to prediction of important health services use in this sample, **Table 2** shows that each 0.10 m/s increase in baseline gait speed was associated with two fewer inpatient rehabilitation visits (primarily physical and occupational therapy visits) and about three fewer inpatient medical-surgical visits. Faster walking speed at hospitalization was also associated with lower costs during the index hospitalization ($1,334 less per each 0.10 m/s increase in baseline gait speed).

Table 3 shows results from longitudinal analyses in which baseline gait speed and 12-month change in gait speed are used to predict 12-month change in health status and disability scores (see **Appendix** for details about units of walking speed; available online only at http://www.vard.org/jour/jourindx.html). **Table 3** suggests that the slower a patient's walking speed at initial hospitalization, the more general health status, specific physical functioning aspects of health status, BADL, and IADL improved during the 12-month follow-up period.

Improvement in walking speed was also associated with improvement in general and physical health status (8.40 and 2.90 standardized units per 0.10 m/s/yr change), and with declines in BADL, IADL, and total ADL disabilities over the 12-month follow-up period. On the other hand, change in gait speed was not strongly associated with number of inpatient rehabilitation or medical-surgical visits. Each 0.10 m/s/yr improvement in the gait speed was associated with approximately 2.3 fewer inpatient hospitalization days and with lower total

Table 3.
Use of gait speed (baseline and absolute change over 1 year) to predict absolute 12-month change in clinical indicators (SF-36, physical function subscale, and disability), inpatient health services use, and total costs (n = 1,388).*

Outcomes	Baseline Gait Speed †(unit = 0.10 m/s) β (95% CI)*	Change in Gait Speed †(unit = 0.10 m/s/yr) β (95% CI)*
Δ SF-36		
Raw	–7.92 (–12.62 to –3.22)	20.00 (14.30 to 25.70)
Standardized	–3.12 (–5.00 to –1.24)	8.39 (6.05 to 10.75)
Δ Physical Function Subscale		
Raw	–2.40 (–3.34 to –1.46)	6.90 (5.91 to 7.89)
Standardized	–0.96 (–1.43 to –0.49)	2.90 (2.51 to 3.29)
Δ Disability		
Basic	0.24 (0.19 to 0.29)	–0.30 (–0.37 to –0.22)
Instrumental	0.04 (–0.06 to 0.14)	–0.70 (–0.82 to –0.58)
Total	0.24 (0.01 to 0.47)	–1.00 (–1.13 to –0.87)
No. Inpatient Rehabilitation Visits	–2.8 (–3.7 to –1.9)	0.36 (–0.31 to 1.02)
No. Inpatient Medical-Surgical Visits	–3.12 (–5.00 to –1.24)	0.50 (–0.36 to 1.36)
Length of Stay (d)	–2.26 (–2.9 to –1.4)	–2.27 (–3.25 to –1.28)
‡Total 1 Yr Costs	–$130 (–$995 to $735)	–$1,188 (–$2,442 to $65)

*All models are adjusted for age, gender, race, education, number of baseline medications, baseline comorbidity, and treatment assignment. β coefficients and 95% confidence intervals (CIs) represent change in outcome per unit change in gait speed.
†See **Appendix** for details of walking speed units (available online only at http://www.vard.org/jour/jourindx.html).
‡Fully adjusted models, including age, gender, race, education, number of baseline medications, baseline comorbidity, treatment assignment, length of stay, baseline gait speed, change in health status, and changes in basic activities of daily living (BADL) and instrumental ADL.
CI = confidence interval, SF-36 = 36-item short form.

1-year costs, even after adjustment for baseline gait speed, LOS, and concurrent changes in SF-36 and ADL. Baseline walking speed remained inversely associated with total costs even after maximal adjustment for gait-speed change, LOS, and change in health status indicators. However, the dollar reduction with each 0.10 m/s difference in baseline walking speed was sharply attenuated in this full model.

DISCUSSION

Our results have important implications for functional assessment of hospitalized older adults. First, gait speed at hospitalization identifies important differences in health status and function among the acutely ill and is associated with health services use and costs during the hospitalization and during the first year posthospitalization. The inverse association reported in **Table 3** has two interpretations: (1) that the health status of slow walkers tended to improve during hospitalization on average, and (2) that the fastest walkers tended to have a negative change and an increase in the number of disabilities during the 12 months posthospitalization. We do not find the latter interpretation to be unusual because the adverse effects of acute hospitalizations have been previously reported [31–32] and are consistent with a decline in the health status and physical function of the older adult, both in response to the acute event as well as to the secondary effects of the hospitalization itself (e.g., incurrence of secondary infections, effects of bed rest and deconditioning, etc.) In this acutely ill sample of GEM patients, the inverse association between baseline gait speed and health status change is partly explained by the large number of hospitalized older adults who walked at very slow speeds at baseline and whose health status improved over time. We do not believe the inverse association is due to regression to the mean. Some of the slow walkers died and a large number remained at the same slow speed with no improvement over time; thus, the slowest walkers were not predestined to have better gait speed and health status at follow-up by mere virtue of their having the lowest gait speed scores and poorest health status at baseline. In addition, regression to the mean would tend to bias associations to the null. Our results suggest that the interpretation of a single measure of gait speed is not straightforward and that more research is needed in this area to determine how gait-speed assessment can help guide care.

The rate of change in gait speed in this sample was associated with important changes in general and physical functional health status and with change in BADL and IADL disability. On the other hand, change in gait speed was not strongly associated with inpatient medical-surgical and rehabilitation visits, at least not at the rates of change observed in this hospital-based sample. At the average rate of gait-speed change estimated for this cohort (0.01 m/s/mo), a hospital stay of median length in this study (10.1 days) may not have allowed a long enough duration for observation of important cumulative changes in walking speed due to hospital-based service provision, or a concomitant decrease in need for services due to the small cumulative improvement observed. The short median LOS of this study may account for the lack of stronger associations between hospital service use and gait-speed change. Nevertheless, gait-speed change remained inversely associated with hospital LOS, such that each estimated improvement of 0.01 m/s/mo (~0.12 m/s/yr) was associated with 2.27 fewer days of care.

The range in the rates of gait-speed change observed in this cohort has important implications for the frequency of assessment in this population. The monthly rates of change that we estimated were very small, ranging from –0.03 m/s/mo to 0.06 m/s/mo (mean = 0.01 m/s/mo). We question whether monthly assessment for such small increments of change would be reliable or clinically meaningful in isolation. However, at these same monthly rates, 1-year absolute changes in walking speed range from –0.36 m/s/yr to 0.72 m/s/yr (mean = 0.12 m/s/yr). Changes of this magnitude are substantial, especially for this acutely ill cohort where the median walking speed at baseline was slower than 0.17 m/s. Our study also suggests changes of this magnitude are important from a clinical and health services perspective. These results suggest that while a single assessment of gait speed may be useful in this population, reassessment while in the hospital, or even at monthly intervals after discharge, may not be optimal for detecting meaningful increments of clinical change in gait speed. Longer intervals are probably necessary for meaningful differences to occur, perhaps even as long as 6 to 12 months if gait speed changes at rates comparable with those observed in this study. However, we caution that rates of change certainly could differ in different populations. In addition, the associations we report assume a linear relationship between walking speed and time. On the other hand, while large interim fluctuations could, at least theoretically, provide additional important information, the slow rates of change we estimated using three observations over a 1-year period suggest that the absolute gait-speed changes observed over shorter time periods will be small.

Our data have important implications for the safety and feasibility with which gait speed can be assessed in hospitalized patients. Trained, but unskilled, staff conducted all the gait-speed assessments for this study with no reported adverse events. Assigning a continuous value equivalent to the slowest possible walking speed to patients who were objectively assessed to walk at speeds 0.17 m/s appears to be a feasible way of tracking continuous improvement over time, though this method is not sensitive to decline in walking speed in the 0 to 0.17 m/s range. We believe decline in walking speed may be irrelevant for this slowest group because walking speeds slower than 0.17 m/s do not appear to be functional [20]. Future studies in acutely ill adults will better establish the proportion that is truly nonambulatory or too sick to complete a walking test while hospitalized. The actual gait speed of acutely ill adults who walk slower than 0.17 m/s might best be determined with a gait speed protocol where times are recorded for all ambulatory individuals (as opposed to the PPT protocol that assigns the slowest walkers to a categorical value), shorter distances are used (i.e., less than 50 ft), or more time is allotted for completion of the test, because this study suggests that a substantial number of hospitalized older adults will walk at speeds less than or equal to 0.17 m/s.

Several important limitations deserve discussion. The first is the inability to distinguish among people who walked between 0 and 0.17 m/s. However, parameter estimates from the sensitivity analysis of our data—under the assumption that all patients who were unable to complete the test in 90 s were actually nonambulatory, i.e., assigned a speed of 0 m/s instead of 0.17 m/s—did not differ substantially from the effects reported in this manuscript (see **Appendix** for results of the sensitivity analysis; available online only at http://www.vard.org/jour/jourindx.html).

Results may not apply to females or to hospital settings outside the VA system, which may have different policies and guidelines for health services use and costs. We were also not able to control for height in our analysis. While height has been shown to partly determine speed of walking [33–34], height should not necessarily be related to health services use and would not be expected to confound our estimates. Nevertheless, adjusting for height could possibly have improved the precision with which we measured gait speed.

CONCLUSIONS

We conclude that gait speed is a useful and clinically important indicator of current health for acutely ill, hospitalized, older adults, predicts 1-year patterns of health and function over time, and may help clinicians identify which patients require additional time in the hospital or additional health services use, ultimately requiring greater monetary expenditures. We echo the recent calls for gait assessment (in particular the measurement of walking speed) to be used routinely in the older adult population [8,35].

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