

Temporal Association Between Hospitalization and Rate of Falls After Discharge

Jane E. Mahoney, MD; Mari Palta, PhD; Jill Johnson, MS, PT; Muhammad Jalaluddin, PhD; Shelly Gray, PharmD; Soomin Park, MS; Mark Sager, MD

Background: Evidence suggests that acute illness and hospitalization may increase the risk for falls.

Objective: To evaluate the rate of falls, and associated risk factors, for 90 days following hospital discharge.

Methods: We consecutively enrolled 311 patients, aged 65 years and older, discharged from the hospital after an acute medical illness and receiving home-nursing services. Patients were assessed within 5 days of discharge for prehospital and current functioning by self-report, and balance, vision, cognition, and delirium by objective measures. Patients were followed up weekly for 13 weeks for falls, injuries, and health care use.

Results: The rate of falls was significantly higher in the first 2 weeks after hospitalization (8.0 per 1000 person-days) compared with 3 months later (1.7 per 1000 person-days) ($P = .002$). Fall-related injuries accounted for 15%

of all hospitalizations in the first month after discharge. Independent prehospital risk factors significantly associated with falls included dependency in activities of daily living, use of a standard walker, 2 or more falls, and more hospitalizations in the year prior. Posthospital risk factors included use of a tertiary amine tricyclic antidepressant, probable delirium, and poorer balance, while use of a cane was protective.

Conclusions: The rate of falls is substantially increased in the first month after medical hospitalization, and is an important cause of injury and morbidity. Posthospital risk factors may be potentially modifiable. Efforts to assess and modify risk factors should be integral to the hospital and posthospital care of older adults (those aged ≥ 65 years).

Arch Intern Med. 2000;160:2788-2795

From the Departments of Medicine (Drs Mahoney and Sager) and Preventive Medicine (Drs Palta and Sager), University of Wisconsin Medical School, Madison; Geriatric Research, Education, and Clinical Center, William S. Middleton Memorial Veterans Hospital, Madison, Wis (Dr Mahoney); the Department of Biostatistics and Medical Informatics, University of Wisconsin, Madison (Dr Palta and Ms Park); New England Center for Integrative Health, Lyme, NH (Ms Johnson); SmithKline Beecham Pharmaceuticals, Philadelphia, Pa (Dr Jalaluddin); and the School of Pharmacy, University of Washington, Seattle (Dr Gray).

FALLING IS a common and serious medical problem for older adults. Although the rate of falls varies significantly with age,¹ approximately one third of community-living adults older than 65 years fall each year.²⁻⁴ Such falls pose serious threats to the health and function of older adults and lead to increased health care costs to society. In those older than 65 years, 1 in 20 hospitalizations is for fall-related injury,⁵ with the average charge per stay being \$11 800.⁶

Few studies have examined the incidence of falls after hospitalization, yet several lines of evidence suggest this may be a high-risk period. First, changes in physical function due to acute illness may predispose to falls.⁷ Second, immobility and bed rest may result in impaired coordination,⁸ increased body sway,⁹ decreased strength,^{10,11} slowed gait speed,⁹ and orthostatic incompetence,^{8,11,12} all of which may increase the risk of falls.^{3,4,13-18} Third, delirium occurs in 14% to 56% of elderly hospitalized patients.¹⁹ Persistence of de-

lirium into the posthospitalization period²⁰ may heighten the risk of falls.²¹ Finally, psychoactive medications are often started during hospitalization.²² Given their known association with falls,²³ they may be an important risk factor for falls after hospital discharge.

In a previous retrospective analysis,²⁴ it was found that older adults who received home-nursing services had a high incidence of falls within the first month after hospitalization compared with those not receiving home-nursing services (20% vs 8%). However, that analysis was limited by a small sample size, lack of memory aids for reporting falls, a short follow-up period, and incomplete characterization of risk factors. We undertook this prospective study to confirm findings and overcome limitations of that previous analysis. We limited this prospective study to higher-risk patients, those receiving home-nursing services after discharge, because it may be most cost-effective to target high-risk patients for intervention. We evaluated falls weekly for 3 months after

PATIENTS AND METHODS

STUDY POPULATION

Patients were consecutively enrolled after hospital discharge from April 11, 1994, to May 9, 1996. **Figure 1** shows the inclusion and exclusion criteria and enrollment statistics. The 613 patients who were contacted were similar in age, race, and sex to those who were not contacted, but were more likely to be married (37% vs 26%; $P = .02$). Of those contacted, the 312 (51%) who accepted were not different from those who refused in age, race, sex, marital status, or length of hospital stay. Informed consent was obtained in accordance with the University of Wisconsin, Madison, Institutional Review Board guidelines.

INITIAL ASSESSMENT

Initial assessment occurred in the patient's home within 5 days of hospital discharge. Subjective measures included self-report of prehospital (for the period 2 weeks before hospitalization) and current function and mobility. Function was assessed for 6 activities of daily living (ADLs).²⁵ Patients were considered independent in ADLs if they were able to perform all 6 activities without help from another person. Mobility questions included use of an assistive device indoors and the ability to walk one block. Patients were also asked about frequency of alcohol intake and episodes of light-headedness when rising from a chair in the month before hospitalization, and about numbers of hospitalizations and falls in the prior year. A caregiver (if residing with the patient) was asked to verify the number of falls in the previous year. Finally, as an indicator of the presence of depression, patients were asked if, since leaving the hospital, they often felt sad or depressed.²⁶

Objective measures at the initial assessment included orthostatic blood pressure and pulse,²⁷ corrected vision at 2.1 m,²⁸ and assessments of cognition using the Mini-Mental State Examination (MMSE),²⁹ balance using the Performance-Oriented Balance Assessment,³⁰ and delirium using the Confusion Assessment Method.³¹ Interrater reliability testing was performed throughout the study. The Pearson product moment correlation for pairs of raters for the Performance-Oriented Balance Assessment (24 pairs) was 0.99, and for determination of possible or probable delirium using the Confusion Assessment Method was 0.93 (14 pairs).

At the home visit, the researcher asked the patients to collect all medications they were taking. Medication information (dose, route, and frequency) was taken directly from medication labels and compared with hospital discharge summary and home health agency records; any discrepancies were resolved by contacting the physician or home nursing agency. Length of hospital stay and diagnoses were abstracted from home-nursing and hospital admission records.

All data were obtained by trained personnel using standardized protocols. For subjective measures, if the patient was deemed unreliable by the interviewer (26% of patients), information was obtained or verified by the caregiver. In a validation subsample, there was complete agreement on prehospital ADL scores in 10 (83%) of 12 patient-caregiver pairs, with disagreement equally likely in both directions.

ASCERTAINMENT OF SUBSEQUENT FALLS

At the initial interview, patients were questioned about falls since hospitalization, and asked to record falls for the next 3 months. Patients were provided with a calendar and a set of 13 weekly postcards.¹⁷ Caregivers were asked to help in calendar and postcard reporting for unreliable patients.^{2,32} If a postcard was not received, the patient was contacted by telephone. Patients were also asked at 1- and 3-month in-person interviews if they had fallen since the index hospitalization. For all patients admitted to a hospital or nursing home during the 3 months, medical records were reviewed for history of falls in the week before facility admission. Of the falls, 8% were ascertained by initial assessment, 57% by postcard, 19% by telephone call, 4% by questioning at 1 and 3 months, and 12% by review of facility records for patients who were hospitalized or admitted to a nursing home.

All positive reports of falls were followed by telephone interview to prevent duplicate reporting, and to ascertain injuries and health service use. Health service use was verified by review of hospital and nursing home records.

DEFINITIONS OF INDEPENDENT VARIABLES

Living arrangement was classified as alone, with spouse, with family, or with hired help (including community-based retirement facility or other paid arrangement). Chronic conditions included congestive heart failure, chronic obstructive pulmonary disease, diabetes mellitus, cerebrovascular accident, and parkinsonism, and were based on either a principal or a secondary diagnosis from hospital admission and home-nursing records. Lower extremity arthritis was based on self-report. Number of diagnoses (a measure of comorbidity) was considered as the number of active diagnoses listed in hospital admission and home-nursing records.

Ambulation aids were classified as cane, wheeled or standard walker, or wheelchair. Patients were considered users of an ambulation aid if they used it more than 50% of the time. History of 2 or more falls in the year prior was based on proxy report if the MMSE score was less than 24. If the MMSE score was 24 or more, or if no proxy were available ($n = 9$), history of prior falls was based on patient report. Exclusion of the 9 patients with poor cognition and no proxy did not substantially affect results. *Probable delirium* was defined as present if there was fluctuation in attention, thinking, or level of consciousness, evidence of inattention, and either disorganized thinking or decrease in the level of consciousness.³¹

Patients were classified as users of a psychotropic medication class if a medication in that class was prescribed (either scheduled or as needed). Medication classes were long- and short-acting benzodiazepines, tertiary amine tricyclic antidepressants (TCAs), secondary amine TCAs, selective serotonin reuptake inhibitors, other antidepressants, and antipsychotic agents.³³ Since dose affects risk for falls, we determined a standardized dose based on the lowest effective dose for each agent using standard references as used by other investigators.³⁴

PRIMARY OUTCOME

The primary outcome was rate of accidental falls in the community during the 3 months after hospital discharge. An

Continued on next page

accidental fall was defined as “an event which results in a person coming to rest inadvertently on the ground or other lower level, and other than as a consequence of the following: sustaining a violent blow; loss of consciousness; sudden onset of paralysis, as in stroke; an epileptic seizure.”^{35(p4)} Determination of overwhelming environmental hazard was based on consensus of a physical therapist and nurse.²

STATISTICAL ANALYSIS

Analyses were based on 311 patients, excluding 1 patient who fell 49 times in the first month. We calculated the rate of falls (number of falls per 1000 patient-days) for each 2-week interval for 3 months after hospital discharge as 1000 times the number of falls in the cohort during the interval divided by the number of days in the community in the interval. Patient-days were censored after death or dropout (6.2% of total days) or when the patient resided in a hospital or nursing home (3.9% of total days), as we were interested in the rate of falls in the community setting, which may differ from that in an institution. Finally, days were censored for which we had no patient information regarding falls from any source (postcard, telephone interview, the 7 days preceding a hospital or nursing home admission, or the 30 days before in-home questioning at 1 and 3 months) (3.1% of total days).

Standard errors for the rates of falls in each interval, adjusted for potential correlation between periods caused by individual propensities to fall, were obtained by a generalized estimating equations method³⁶ by Poisson regression with logarithmic link and independence working correlation. An offset variable was used to account for excluded days. The modeling was implemented by SAS statistical software (PROC GENMOD).³⁷ Rates and SEs were determined for the full cohort, and determined again, excluding patients whose falls were discovered only by medical record review. This only slightly decreased the rate of falls. To ensure that change in rate of falls over time was not due to differential loss of fallers from the sample, we also repeated analysis excluding patients who had more than 10 censored days (ie, days not in the community). Reasons for more than 10 censored days were as follows: death (6%), hospitalization or nursing home admission (10%), dropout (4%), and missing (3%). Finally, to ensure there was no bias due to differential sources of information during the study, we recalculated the rate of falls, including only patients (67.2%) for whom information was available by postcard or telephone call for the complete 90 days. There

was no substantial change in the pattern of rate of falls over time with any of these subanalyses. The results using time as an ordinal variable were similar to those of coding intervals by indicator variables.

To evaluate risk factors for falls, we used the full cohort ($n=311$), including those with less than 90 days in the community. The full cohort was used because of concern that risk factors may go undetected if they increase the likelihood of falls and exit from the community. We used univariate and multivariate Poisson regression models, with the number of falls in each 2-week interval as the outcome. Rate ratios and corresponding 95% confidence intervals associated with risk factors were obtained by exponentiating the regression coefficients and their robust confidence limits.

Continuous variables were modeled as continuous and categorical to determine the best fit (ie, the lowest log likelihood). For categorical modeling, accepted cutoffs were used (eg, MMSE score); otherwise, variables were classified into tertiles. Results were consistent using either method.

Two models were developed. Model 1 consisted of prehospital predictors only. We began by including prehospital predictors that were significant in univariate analysis, retaining those that remained significant in the model. Then, other prehospital predictors (not significant in univariate analysis) were added sequentially, and retained if significant. Finally, chronic conditions and demographic characteristics were tested and retained if significant. After adding each new variable, we retested all variables not in the model. Level of significance was set at $P<.05$.

For model 2, we added significant hospital and posthospital predictors to the prehospital model, following the same procedure as previously described. For both models, all pairwise interactions were tested, and included if $P<.05$ for the interaction term. For discrete variables, we only considered interactions if each subgroup formed by variable level combinations contained 10 individuals or more.

After developing models 1 and 2, we added time after hospitalization coded as an ordinal variable. Interaction effects between time and each risk factor in models 1 and 2 were tested.

Source of data reporting (patient or caregiver), source of referral to the study (ie, home-nursing agency), and originating hospital were tested as possible confounders in both models. There was no change in the regression coefficients of other variables when these variables were included, nor were they statistically significant. They were, therefore, excluded from the final models.

hospitalization to test the hypothesis that the rate of falls would decrease as patients recovered from acute illness.

RESULTS

RATE OF FALLS AFTER HOSPITALIZATION

Table 1 shows the demographic characteristics and prevalence of chronic conditions for the sample. Most subjects were females; 54% lived with others.

In the first month after discharge, 46 (14.8%) of the 311 patients fell. Thirty-three people fell once;

9, twice; and 4, 3 or more times. The percentage of patients who fell decreased in succeeding months; 7.0% fell in the second month, and 5.4% fell in the third month.

Figure 2, left, shows the rate of falls after hospital discharge. In the first 2 weeks after discharge, there were 8 falls per 1000 person-days. The rate of falls decreased rapidly to 2.5 falls per 1000 person-days by 8 weeks after discharge. Figure 2, right, shows that for the subgroup of patients who were in the community for at least 80 of 90 days ($n=238$), there was a similar decline in rate of falls over time.

INJURIES ASSOCIATED WITH FALLS

Eleven percent of falls in the first month resulted in serious injury requiring hospitalization. Serious injury included fractures of the ankle, pelvis, spine, and arm; a dislocated hip prosthesis; severe bruising; and head laceration. The 7 resulting hospitalizations totaled 29 days and led to 3 subsequent nursing home admissions totaling 70 days. Injuries due to falls accounted for 15% of all hospitalizations in the first month.

Of the 67 falls in the first month, 14 (21%) resulted in minor injuries, primarily bruises and abrasions. A fall was as likely to result in injury in the third month as the first month. However, as there were fewer falls, there were fewer numbers of injuries in months 2 and 3. Injuries due to falls accounted for 2.4% of hospitalizations in the second month and 4.5% in the third month.

RISK FACTORS FOR FALLS

Table 2 shows the unadjusted associations of prehospital, hospital, and posthospital factors with rate of falls after discharge. Model 1 in **Table 3** shows prehospital

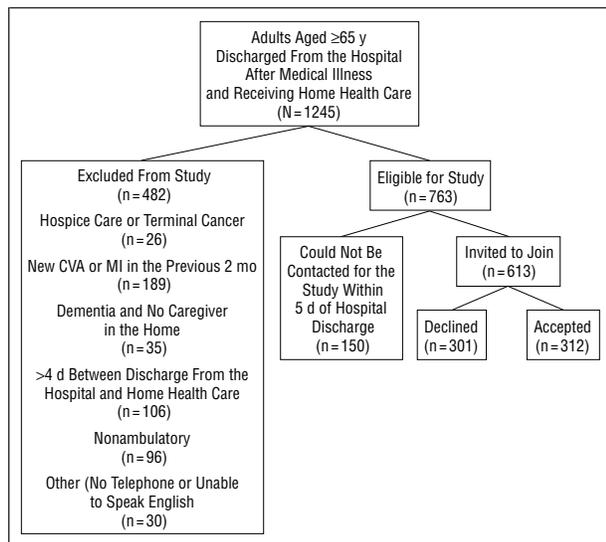


Figure 1. Enrollment criteria and statistics. CVA indicates cerebrovascular accident; MI, myocardial infarction.

risk factors for falls in multiple regression analysis, controlling for sex. In model 1, preexisting use of a standard walker, ADL dependency before hospitalization, 2 or more falls, and greater number of hospitalizations in the prior year were independently associated with an increased rate of falls after discharge. No other prehospital factors from Table 2 were significant in the model. There were no significant interaction effects in model 1.

Model 2 in Table 3 adds significant hospital and posthospital factors, again controlling for sex. An admitting diagnosis involving the gastrointestinal tract was associated with an increased risk for falls after discharge. Posthospital factors associated with increased risk in-

Table 1. Characteristics of the 311 Study Participants

Characteristic	Variable*
Age, mean ± SD, y	80.0 ± 7.1
Female sex	62.8
Race	
White	96.8
African American	2.2
Marital status	
Widowed	50.3
Married	38.8
Divorced	4.8
Single	6.1
Living arrangement	
Alone	45.5
Spouse	34.6
Family	14.7
Hired help†	5.1
Type of housing	
Own home or apartment	88.7
Housing with senior services	6.4
Community-based retirement facility	4.8
Chronic conditions	
Congestive heart failure	34.9
Chronic obstructive pulmonary disease	34.3
Diabetes	24.4
Lower extremity arthritis	39.5
Past stroke	9.9
Parkinsonism	2.6

*Data are given as percentage of participants unless otherwise indicated. Percentages do not total 100 due to rounding (living arrangement and type of housing) or because of a small percentage (race).

†Includes community-based retirement facility or other paid arrangement.

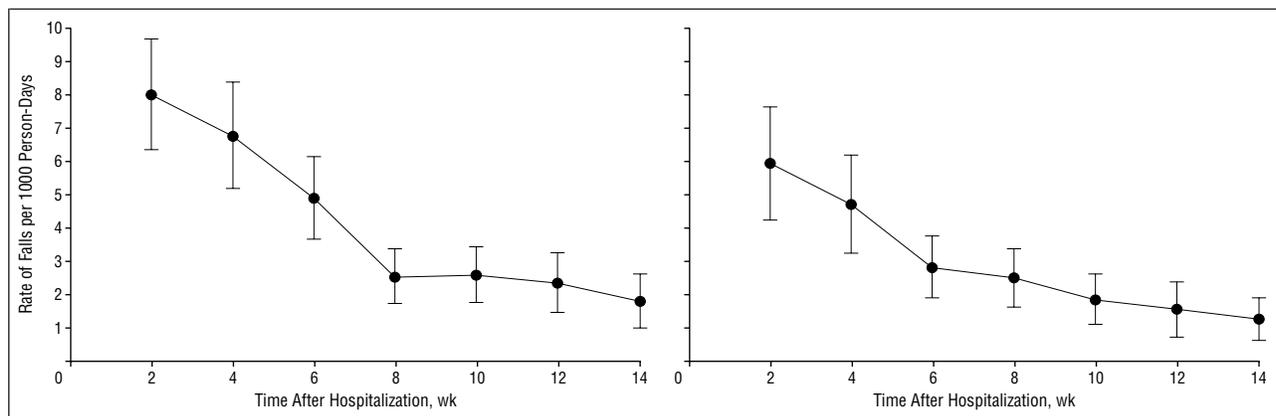


Figure 2. Rates of falls for the full sample (n=311) (left) and for a subgroup with 80 days or more in the community (n=238) (right). Vertical bars represent SEs.

Table 2. Prehospital, Hospital, and Posthospital Factors Singly Associated With Falls in the 3 Months After Hospital Discharge for the 311 Study Participants

Factor	Variable*	Rate Ratio (95% CI)
Prehospital		
≤2 wk prior		
Dependent in ≥1 ADLs†	25.6	3.58 (2.14-5.98)
Used ambulation aid indoors		
Cane	14.5	0.84 (0.39-1.80)
Standard walker	6.8	4.48 (2.09-9.59)
None	65.5	Reference
Could not walk one block	64.3	1.77 (1.02-3.06)
Was light-headed with standing	68.8	1.59 (0.93-2.73)
Drank alcohol daily	7.4	2.00 (0.72-5.55)
Had a corrected distant visual acuity of 20/50 or worse‡	33.4	1.38 (0.80-2.39)
≤1 y prior		
Had ≥2 falls	20.5	2.96 (1.73-5.06)
No. of prior hospitalizations, mean ± SD§	0.84 ± 1.29	1.22 (1.12-1.34)
Hospital		
Admitting diagnosis		
Cardiovascular	19.3	1.07 (0.50-2.27)
Pulmonary	24.1	0.94 (0.46-1.91)
Gastrointestinal tract	11.9	1.81 (0.83-3.94)
Neurologic	10.0	0.84 (0.22-3.20)
Other	34.7	Reference
No. of diagnoses at admission, mean ± SD§	7.09 ± 2.73	1.06 (0.96-1.19)
Length of stay, mean ± SD, d§	6.86 ± 4.73	1.03 (0.98-1.08)
Posthospital		
No. of prescribed medications, mean ± SD§	6.11 ± 3.08	1.01 (0.92-1.22)
No. of new medications, mean ± SD§	1.86 ± 1.63	0.99 (0.82-1.18)
No. of psychoactive medications, mean ± SD§	0.58 ± 0.92	1.17 (0.95-1.46)
Medication class prescribed		
Cardiovascular	83.3	0.60 (0.30-1.22)
Long-acting benzodiazepine	2.9	1.34 (0.41-4.42)
Short-acting benzodiazepine¶	15.1	1.20 (0.57-2.55)
Tertiary amine tricyclic antidepressant#	5.8	2.60 (1.26-5.34)
Other antidepressant**	12.6	0.78 (0.66-1.74)
Antipsychotic††	2.3	2.15 (0.74-6.30)
Dependent in ADLs	52.6	2.33 (1.32-4.11)
Uses ambulation aid indoors		
Cane	16.3	0.46 (0.19-1.12)
Standard walker	14.1	1.64 (0.73-3.68)
None	48.1	Reference
Cannot walk 1 block	82.7	1.02 (0.56-1.90)
Balance tertile score‡‡		
Lowest (0-18)	32.2	3.75 (1.88-7.48)
Middle (19-22)	31.8	2.28 (1.07-4.84)
Highest (23-26)	32.2	Reference
Mini-Mental State Examination score (maximum = 30), mean ± SD§	26.0 ± 3.90	1.09 (1.04-1.14)
Probable delirium	1.6	4.11 (0.85-19.79)
Feels sad or depressed	27.1	1.28 (0.69-2.38)
Orthostatic systolic BP decrease ≥20 mm Hg	11.1	0.77 (0.36-1.66)

*Data are given as percentage of participants unless otherwise indicated. CI indicates confidence interval; ADL, activity of daily living; and BP, blood pressure.

†There are 6 ADLs (bathing, dressing, eating, toileting, and transferring and walking across a small room).

‡n = 304 (7 participants refused or could not perform because of aphasia).

§The rate ratio is for each additional unit of measurement (eg, for each additional hospitalization compared with the hospitalization before).

||The average standardized daily dose is 1.1 (5 mg of diazepam is 1 standard daily dose).

¶The average standardized daily dose is 1.1 (15 mg of temazepam is 1 standard daily dose).

#The average standardized daily dose is 0.7 (75 mg of amitriptyline hydrochloride is 1 standard daily dose).

**The average standardized daily dose is 1.1 for other tricyclic antidepressants, 1.0 for selective serotonin reuptake inhibitors, and 0.79 for other antidepressants (37.5 mg of nortriptyline hydrochloride and 20 mg of fluoxetine is 1 standard daily dose).

††The average standardized daily dose is 0.5 (2 mg of haloperidol is 1 standard daily dose).

‡‡Performance-Oriented Balance Assessment; the maximum score is 26. n = 299 (12 patients who refused the test or had medical contraindication were retained in the analysis as a separate balance category).

cluded using a tertiary amine TCA, having probable delirium, and having poorer balance. One posthospital factor was protective: use of a cane at discharge decreased risk compared with no assistive device.

Use of a tertiary amine TCA remained a significant risk factor after adjusting for depression, diabetes, and neuropathy. The average standardized dosage of tertiary amine TCAs was similar to that of other TCAs (0.7

Table 3. Independent Factors Associated With Increased Rate of Falls in the 3 Months After Hospital Discharge for the 311 Study Participants*

Risk Factor	Rate Ratio (95% CI)†	
	Model 1	Model 2
Prehospital		
Dependent in ≥1 ADLs‡	2.74 (1.57-4.76)	2.34 (1.33-4.13)
Used standard walker indoors§	2.35 (1.11-4.96)	3.26 (1.62-6.53)
Had ≥2 falls in year prior	2.04 (1.23-3.40)	1.66 (1.04-2.65)
No. of hospitalizations in year prior	1.14 (1.02-1.27)	1.12 (1.02-1.22)
Hospital		
Admission gastrointestinal tract diagnosis¶	...	2.51 (1.30-4.86)
Posthospital		
Tertiary amine tricyclic antidepressant#	...	3.16 (1.77-5.65)
Uses cane indoors§	...	0.32 (0.12-0.84)
Balance score**		
Middle tertile	...	2.21 (1.01-4.81)
Lowest tertile	...	3.32 (1.57-6.99)
Probable delirium	...	6.66 (2.16-20.51)

*CI indicates confidence interval; ADL, activity of daily living; and ellipses, data not applicable.

†Both models were adjusted for sex and all other factors in the model.

‡There were 6 ADLs (bathing, dressing, eating, toileting, and transferring and walking across a small room).

§Relative to using no assistive device.

||The rate ratio is for each additional hospitalization.

¶Relative to other diagnoses (noncardiac, nonpulmonary, non-gastrointestinal tract, and nonneurologic).

#Amitriptyline hydrochloride, doxepin hydrochloride, imipramine hydrochloride, or protriptyline hydrochloride.

**The rate ratio for each tertile is relative to the highest tertile of balance. The lowest tertile indicates a score of 0 to 19 on the Performance-Oriented Balance Assessment; and the middle tertile, a score of 19 to 22 (maximum score, 26).

vs 1.1, respectively). When other types of antidepressants (selective serotonin reuptake inhibitors [used by 5.5%], secondary amine TCAs (2.3%), trazadone hydrochloride (3.9%), and others (venlafaxine hydrochloride or bupropion hydrochloride [1.0%]) were evaluated as distinct classes, they were not significantly associated with falls in univariate or multivariate analyses. Average standardized doses were similar for other antidepressants.

Figure 3 shows the change in rate of falls over time comparing patients with and without prehospital ADL dependency, adjusting for all factors in model 2. Patients with prehospital ADL dependency had a marked increase in rate of falls early after hospital discharge, with the rate of falls decreasing steeply over time. Other risk factors in models 1 and 2 showed a similar trend in change in rate of falls over time.

COMMENT

To our knowledge, this is the first study to specifically examine the incidence of falls in older, recently hospitalized, medical patients requiring postdischarge home care. This represents a substantial patient population, as 33% to 44% of hospitalized older adults receive home health services following discharge from the hospi-

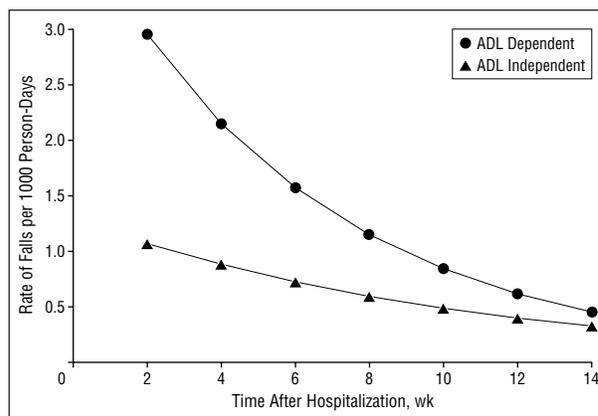


Figure 3. Rates of falls for patients with and without prehospital activities of daily living (ADL) dependency.

tal.^{24,38} The fall rate was more than 4-fold higher in the first 2 weeks after hospitalization compared with 3 months after discharge. This temporal association between hospital discharge and the risk of falls suggests a causal relation between illness, hospitalization, or both and the rate of posthospital falls. The deconditioning effects of bed rest, iatrogenic complications of diagnostic and therapeutic interventions, and the effects of acute illness could all have contributed to the risk of posthospital falls and fall-related injuries.³⁹ In the first month after discharge, 11% of falls resulted in serious injury requiring hospitalization, and fall injury-related hospitalizations accounted for 15% of all rehospitalizations during this period.

In our study, patients at high risk could be identified by factors present on admission and at discharge. Patients who were dependent in 1 or more ADLs before hospitalization, had a history of previous falls, or had preexisting mobility impairments, as suggested by the use of a standard walker, were at high risk for posthospital falls. In addition, prior hospitalization was a risk factor, suggesting an aggregate effect of hospital-associated losses in function and mobility^{40,41} that may have contributed to the increased posthospital falls risk documented by this study.

Patients with delirium, and those receiving tertiary amine TCAs, were also at increased risk for falls after hospitalization. Delirium has been shown to be a risk factor for in-hospital falls.²¹ Our study suggests that persistent or new delirium after hospitalization²⁰ places patients at 6-fold higher risk. Tertiary amine TCAs have anticholinergic, orthostatic, and sedating adverse effects, which may account for the relation between their use and posthospital falls. Others⁴² have recommended that tertiary amine TCAs be avoided in elderly patients; our data support this recommendation.

In addition to prehospital risk factors for falls, patients with poorer balance scores at discharge were at increased risk for falls after hospitalization. Although we were unable to assess prehospital balance, it is likely that patients' balance was worsened by bed rest, which has been shown to negatively affect coordination and body sway.^{8,9,37} Persistent acute illness may also play a role in worsening balance. Use of a cane after hospitalization was

protective. These findings suggest that efforts to improve balance and increase the use of ambulation aids after hospitalization may reduce the risk of falls after discharge. Both may be low-cost but high-yield interventions that could be included as part of pre-discharge or postdischarge treatment for this group of patients.

In this study, an admission gastrointestinal tract diagnosis was associated with increased posthospital falls. Although this may have been due to chance, it may indicate effects related to short-term blood loss or other factors we were unable to measure. Certainly, this finding requires validation in other studies.

There are several limitations to this study. First, assessment of prehospital risk factors was based on self-report, and potentially subject to recall bias. However, we compared patients' and proxies' reports of patients' function before hospitalization and found no obvious bias in reporting. To improve reporting of prior falls, we used longer reporting periods and proxies for patients with lower MMSE scores.⁴³ Second, dating falls may be problematic, but most falls (96%) were identified by weekly postcards or telephone calls, which should provide greater accuracy.³² Third, practices of home-nursing referral may vary; however, we found no significant differences in fall rates based on referral source or index hospitalization after adjusting for other risk factors. This suggests that we were able to identify important predisposing characteristics that may apply independent of home-nursing practices. Fourth, we were unable to determine whether the increased falls risk was related to acute illness or to hospital-associated processes such as bed rest, iatrogenic illness, and complications of therapeutic and diagnostic interventions. This is an important area for future study.

The response rate in our study is similar to that found in other studies⁴⁴⁻⁴⁷ that have targeted hospitalized older adults with high degrees of frailty. We found the most common reason for refusal was inability to meet with the investigator in the required time (within 5 days of hospital discharge). In many cases, patients did not enroll with the home-nursing agency until the third or fourth day after discharge. This left only 1 to 2 days for patients to enroll and for us to perform the initial assessment. We think it unlikely that our findings were biased by the refusal rate. First, illness was not frequently given as a reason for refusal. Second, there were no significant differences in demographic characteristics or length of hospital stay between patients who refused and those who enrolled, suggesting that our sample was representative.

In summary, this study demonstrates several important findings. First, older adults receiving home-nursing care after medical hospitalization have a high rate of falls and fall-related injuries. Second, patients at high risk for posthospital falls can be identified on hospital admission and at discharge. Third, many of the risk factors for posthospital falls may be potentially preventable. Given the high rate of posthospital falls and associated high morbidity and costs, efforts to assess and modify risk factors should be integral to the hospital and posthospital care of older adults.

Accepted for publication March 3, 2000.

This study was supported by a grant from the Foundation for Physical Therapy, Alexandria, Va; a grant from the Dean Foundation, Madison, Wis; a grant from the University of Wisconsin Medical School and Graduate School, Madison; and Clinical Investigator Award K08AG00623 (Dr Mahoney) and Clinical Investigator Award K08AG00808-01 (Dr Gray) from the National Institute on Aging, Bethesda, Md.

Presented in part at the 51st Annual Meeting of the Gerontological Society of America, Philadelphia, Pa, November 21, 1998.

We thank Diane Krueger for coordination of the study; Jan Eisner, RN, Trisha Crinkley, Sue Rosa, OT, John Hoffman, Naomi Parella, Rhonda White, and LuAnn Tammany, PT, for recruitment and data collection; and the staff members of Home Health United, Visiting Nurse Service, and UW Home Health for the referral of patients.

Reprints: Jane E. Mahoney, MD, Department of Medicine, University of Wisconsin Medical School, 2870 University Ave, Suite 100, Madison, WI 53705 (e-mail: jemahone@facstaff.wisc.edu).

REFERENCES

1. Campbell AJ, Borrie BJ, Spears GF, Jackson SL, Brown JS, Fitzgerald JL. Circumstances and consequences of falls experienced by a community population 70 years and over during a prospective study. *Age Ageing*. 1990;19:136-141.
2. Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. *N Engl J Med*. 1988;319:1701-1707.
3. Blake AJ, Morgan K, Bendall MJ, et al. Falls by elderly people at home: prevalence and associated factors. *Age Ageing*. 1988;17:365-372.
4. Campbell AJ, Borrie MJ, Spears GF. Risk factors for falls in a community-based prospective study of people 70 years and older. *J Gerontol*. 1989;44:M112-M117.
5. Alexander BH, Rivara FP, Wolf ME. The cost and frequency of hospitalization for fall-related injuries in older adults. *Am J Public Health*. 1992;82:1020-1023.
6. Covington DL, Maxwell JG, Clancy TV. Hospital resources used to treat the injured elderly at North Carolina trauma centers. *J Am Geriatr Soc*. 1993;41:847-852.
7. Tinetti ME, Speechley M. Prevention of falls among the elderly. *N Engl J Med*. 1989;320:1055-1059.
8. Taylor H, Henschel A, Brozek J. Effects of bed rest on cardiovascular function and work performance. *J Appl Physiol*. 1949;2:223-239.
9. Dupui P, Montoya R, Costes-Salon MC, Severac A, Guellet A. Balance and gait analysis after 30 days -6° bed rest: influence of lower-body negative-pressure sessions. *Aviat Space Environ Med*. 1992;63:1004-1010.
10. Suzuki Y, Murakami T, Haruna Y, et al. Effects of 10 and 20 days bed rest on leg muscle mass and strength in young subjects. *Acta Physiol Scand*. 1994;150 (suppl 616):5-18.
11. Deitrick JE, Whedon GD, Shorr E. Effects of immobilization upon various metabolic and physiologic functions of normal men. *Am J Med*. 1948;4:3-36.
12. Greenleaf JE. Physiological responses to prolonged bed rest and fluid immersion in humans. *J Appl Physiol*. 1984;57:619-633.
13. Lord SR, Clark RD, Webster IW. Physiological factors associated with falls in an elderly population. *J Am Geriatr Soc*. 1991;39:1194-1200.
14. Whipple RH, Wolfson LI, Amerman PM. The relationship of knee and ankle weakness to falls in nursing home residents: an isokinetic study. *J Am Geriatr Soc*. 1987;35:13-20.
15. Lipsitz LA, Jonsson PV, Kelley MM, Koestner JS. Causes and correlates of recurrent falls in ambulatory frail elderly. *J Gerontol*. 1991;46:M114-M122.
16. Tinetti ME, Williams TF, Mayewski R. Fall risk index for elderly patients based on number of chronic disabilities. *Am J Med*. 1986;80:429-434.
17. Nevitt MC, Cummings SR, Kidd S, Black D. Risk factors for recurrent nonsyncope falls: a prospective study. *JAMA*. 1989;261:2663-2668.
18. Lord SR, Lloyd DG, Li SK. Sensori-motor function, gait patterns and falls in community-dwelling women. *Age Ageing*. 1996;25:292-299.
19. Inouye SK. The dilemma of delirium: clinical and research controversies regarding diagnosis and evaluation of delirium in hospitalized elderly medical patients. *Am J Med*. 1994;97:278-288.

20. Levkoff SE, Evans DA, Liptzin B, et al. Delirium: the occurrence and persistence of symptoms among elderly hospitalized patients. *Arch Intern Med.* 1992;152:334-340.
21. Francis J, Martin D, Kapoor WN. A prospective study of delirium in hospitalized elderly. *JAMA.* 1990;263:1097-1101.
22. Beers MH, Dang J, Hasegawa J, Tamai IY. Influence of hospitalization on drug therapy in the elderly. *J Am Geriatr Soc.* 1989;37:679-683.
23. Leipzig RM, Cumming RG, Tinetti ME. Drugs and falls in older people: a systematic review and meta-analysis, I: psychotropic drugs. *J Am Geriatr Soc.* 1999;47:30-39.
24. Mahoney J, Sager M, Dunham NC, Johnson J. Risk of falls after hospital discharge. *J Am Geriatr Soc.* 1994;42:269-274.
25. Katz S, Downs TD, Cash HR, Grotz RC. Progress in development of the index of ADL. *Gerontologist.* 1970;20:20-30.
26. Mahoney J, Drinka TJK, Abler R, et al. Screening for depression: single question vs GDS. *J Am Geriatr Soc.* 1994;42:1006-1008.
27. Ensrud KE, Nevitt MC, Yunis C, Hulley SB, Grimm RH, Cummings SR, for the Study of Osteoporotic Fractures Research Group. Postural hypotension and postural dizziness in elderly women: the study of osteoporotic fractures. *Arch Intern Med.* 1992;152:1058-1064.
28. Early Treatment Diabetic Retinopathy Study Coordinating Center. *Manual of Operations.* Baltimore, Md: Diabetic Retinopathy Study Coordinating Center; 1985: chap 13.
29. Folstein MF, Folstein SE, McHugh PR. "Mini-Mental State": a practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res.* 1975;12:189-198.
30. Tinetti ME. Performance-oriented assessment of mobility problems in elderly patients. *J Am Geriatr Soc.* 1986;34:119-126.
31. Inouye SK, Van Dyck CH, Alesi CA, Balkin S, Siegel AP, Horwitz RI. Clarifying confusion: the Confusion Assessment Method: a new method for detection of delirium. *Ann Intern Med.* 1990;113:941-948.
32. Nevitt MC. Ascertainment and description of falls among older persons by self-report. In: Weindruch R, Hadley EC, Ory MG, eds. *Reducing Frailty and Falls in Older Persons.* Springfield, Ill: Charles C Thomas Publisher; 1991:476-495.
33. McEvoy GK, Litvak K, Welsh OH, eds. *American Hospital Formulary Service Drug Information.* Bethesda, Md: American Society of Health-System Pharmacists Inc; 1998.
34. Ray WA, Griffin MR, Schaffner W, Baugh DK, Melton LJ III. Psychotropic drug use and the risk of hip fracture. *N Engl J Med.* 1987;316:363-369.
35. Kellogg International Work Group on the Prevention of Falls in the Elderly. The prevention of falls in later life. *Dan Med Bull.* 1987;34(suppl 4):1-24.
36. Liang KY, Zeger SL. Longitudinal data analysis using generalized linear models. *Biometrika.* 1986;73:13-22.
37. SAS Institute Inc. *SAS/STAT User's Guide, Version 6.* 4th ed. Vol 1 and 2. Cary, NC: SAS Institute Inc; 1989.
38. Solomon DH, Wagner DR, Marenberg ME, Acampora D, Cooney LM, Inouye SK. Predictors of formal home health care use in elderly patients after hospitalization. *J Am Geriatr Soc.* 1993;41:961-966.
39. Mahoney JE. Immobility and falls. *Clin Geriatr Med.* 1998;14:699-726.
40. Sager MA, Rudberg MA. Functional decline associated with hospitalization for acute illness. *Clin Geriatr Med.* 1998;14:669-679.
41. Mahoney JE, Sager MA, Jalaluddin M. New walking dependence associated with hospitalization for acute medical illness: incidence and significance. *J Gerontol.* 1998;53A:M307-M312.
42. Beers MH. Explicit criteria for determining potentially inappropriate medication use by the elderly: an update. *Arch Intern Med.* 1997;157:1531-1536.
43. Cummings SR, Nevitt MC, Kidd BS. Forgetting falls: the limited accuracy of recall of falls in the elderly. *J Am Geriatr Soc.* 1988;36:613-616.
44. Pompei P, Foreman M, Rudberg MA, Inouye SK, Braund V, Cassel CK. Delirium in hospitalized older persons: outcomes and predictors. *J Am Geriatr Soc.* 1994;42:809-815.
45. Siu AL, Kravitz RL, Keeler E, et al. Postdischarge geriatric assessment of hospitalized frail elderly patients. *Arch Intern Med.* 1996;156:76-81.
46. Bull MJ. Use of formal community services by elders and their family caregivers 2 weeks following hospital discharge. *J Adv Nurs.* 1994;19:503-508.
47. Naylor MD, Brooten D, Campbell R, et al. Comprehensive discharge planning and home follow-up of hospitalized elders: a randomized clinical trial. *JAMA.* 1999;281:613-620.