A Case-control Study of Patient, Medication, and Care-related Risk Factors for Inpatient Falls

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OBJECTIVE: To comprehensively analyze potential risk factors for falling in the hospital and describe the circumstances surrounding falls.

DESIGN: Case-control study. Data on potential risk factors and circumstances of the falls were collected via interviews with patients and/or nurses and review of adverse event reports, medical records, and nurse staffing records.

SETTING: Large urban academic hospital.

PATIENTS: Ninety-eight inpatients who fell and 318 controls matched on approximate length of stay until the index fall.

MEASUREMENTS AND MAIN RESULTS: In a multivariate model of patient-related, medication, and care-related variables, factors that were significantly associated with an increased risk of falling included: gait/balance deficit or lower extremity problem (adjusted odds ratio [aOR], 9.0; 95% confidence interval [CI], 2.0 to 41.0), confusion (aOR, 3.6; 95% CI, 1.6 to 8.4), use of sedatives/hypnotics (aOR, 4.3; 95% CI, 1.6 to 11.5), use of diabetes medications (aOR, 3.2; 95% CI, 1.3 to 7.9), increasing patient-to-nurse ratio (aOR, 1.6; 95% CI, 1.2 to 2.0), and activity level of "up with assistance" compared with "bathroom privileges" (aOR, 8.7; 95% CI, 2.3 to 32.7). Urinary or stool frequency or incontinence was of borderline significance (aOR, 2.3; 95% CI, 0.99 to 5.6). Having one or more side rails raised was associated with a decreased risk of falling (aOR, 0.006; 95% CI, 0.001 to 0.024).

CONCLUSIONS: Patient health status, especially abnormal gait or lower extremity problems, medications, as well as care-related factors, increase the risk of falling. Fall prevention programs should target patients with these risk factors and consider using frequently scheduled mobilization and toileting, and minimizing use of medications related to falling.

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Falls are the most common type of inpatient accident, with falls reportedly accounting for up to 70% of inpatient accidents.[1,2] Such falls can result in serious physical and emotional injury, poor quality of life, increased length of stay in the hospital, admission to a long-term care facility, and increased cost.[3–9] Approximately 30% of hospital patient falls result in physical injury, with 4% to 6% resulting in serious injury.[10,11] Due to the risk of significant injury and the increased cost, reduction of falls in hospitals is a major priority for hospital quality and patient safety.

While falls have been relatively well studied in community and nursing home settings, less is known about the prevention of hospital falls. Previous research has identified risk factors for falling in the hospital, including impaired balance or gait, history of falling, increasing age, impaired cognition, depression, dizziness or vertigo, orthostatic hypotension, visual impairment, urinary frequency, nocturia, incontinence, specific diagnoses, and use of certain medications, such as benzodiazepines, antipsychotics, and sedatives.[10,12–18] Yet comparative studies on hospital falls have been limited in several ways, including variations in study design, setting, patient population, and definitions of risk factors. Some studies have continued to focus solely on the elderly or relied only on data included in hospital incident reports or chart review. Furthermore, environmental and care-related factors, including patient-to-nurse ratio, are often overlooked as potential risk factors for falling in these studies.

Because fall prevention programs should be linked to the etiologic factors of falls, further research is required to confirm the common circumstances and risk factors, both patient-related and environmental or care-related, associated with hospital falls, and thus suggest effective elements for fall prevention. We recently reported findings on a study of 183 inpatients who fell at a large academic hospital. Many falls occurred unassisted and were related to elimination-related needs.[19] Elimination-related falls also increased the likelihood of the patient suffering an injury from the fall. To further examine inpatient falls at this hospital, we conducted a case-control study of patients who fell while hospitalized to determine the specific activity and environmental circumstances surrounding inpatient falls and to determine the independent patient-related, medication, and care-related predictors of inpatient falls.

METHODS

Study Design, Setting, and Participants

A case-control study of hospitalized patients who fell was conducted at Barnes-Jewish Hospital (BJH), a 1,300-bed tertiary teaching hospital affiliated with Washington University School of Medicine in St. Louis, Missouri. A total of 951 falls were reported at BJH in 2002, with a hospital-wide fall rate of 3.29 falls per 1,000 patient days. This study included inpatient falls

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that were reported into the hospital's online adverse event reporting system from June 6 through July 18, 2003.

Falls are defined within the adverse event reporting system as a sudden unexpected descent from a standing, sitting, or horizontal position, including slipping from a chair to the floor, patients found on the floor, and falls that occur while the patient is being assisted by hospital staff. Inpatients age 18 years and older were eligible for the study. Falls reported for the medicine, cardiology, neurology, orthopedics, surgery, oncology, and psychiatry services were included. Falls in the obstetrics service were excluded because these falls are rare and consist mostly of babies who fall out of their mother's bed. Falls that occurred during physical therapy sessions were also excluded because such sessions encourage patients to engage in activities that could cause postural instability, often resulting in the physical therapist lowering a patient to the floor without bodily harm.

A total of 106 falls were reported into the adverse event database during the 6-week study period and met our inclusion criteria. For a comparison group, 3 control subjects per case were selected randomly from all hospital inpatients and matched to cases on approximate length of stay (duration of hospitalization from admission to date of index fall). Recruitment of controls for psychiatry patients who fell was restricted to the psychiatry service. This resulted in a total of 318 controls. The 106 falls occurred in 98 patients, 8 of whom fell twice. We analyzed only the first falls for these 98 patients. Second falls were excluded to reduce bias for patient characteristics and because patients who fall multiple times tend to repeat the type and location of the fall on successive falls.[20]

This study was reviewed and approved by the Washington University Institutional Review Board. The need for written informed consent from patients who fell was waived because this study was part of a hospital-based quality improvement project and posed no risk to patients. Cases and controls were informed of the study and provided their implied consent by continuing to participate in the interviews.

Data Collection

A data collection instrument developed by the study team was employed to collect numerous variables from patients who fell and controls. Variables collected are included in Table 1. Potential risk factors collected for both cases and controls included demographics, several health status variables, mental status, and medications used in the 24 hours before the fall or interview (for controls). Data were also collected on the patients' environment and care, such as call light use, assigned activity level, bed information, floor type, footwear, bathroom facilities, fall prevention measures in place, and staffing. For patients who fell, the tool included variables that described circumstances of the fall, such as the location and time of the fall, how the fall was discovered, whether the fall was assisted, the activity being performed when the fall occurred, what triggered the fall, and whether the fall was related to toileting needs (which included getting out of bed for toileting needs, being en route to the bathroom or bedside commode, or using the toilet or bedside commode).

Data were collected for falls and controls using several sources: interviewing the patient or someone close to the patient (relative or friend), interviewing the patient's nurse, consulting the adverse event database, consulting the electronic nursing charting system, and consulting the patient's paper medical record. Data collectors attempted to interview the cases and controls immediately after receiving a report of a fall from the adverse event reporting system to facilitate collecting information first-hand before the patients were discharged. Patients who fell were interviewed a median of 1 day following the fall due to the lag of time between the patient falling and our receipt of the fall report. Controls were interviewed on the day that they became eligible to be a match for a control based on approximate length of stay.

Data collectors were able to interview the patient or a family member/visitor for 35% of cases and 68% of controls. The patient's nurse was interviewed for 62% of cases and 43% of controls. Through interviews, data collectors could identify the type of fall, what triggered the fall, contributing factors to the fall, and some health status variables. Adverse event reports provided information for all cases regarding circumstances of the fall, bed information, and call light availability.

Table 1. Variables on Fall Data Collection Instrument

Variables collected for both controls and patients who fell
Patient demographics*
Health status variables†‡
Mental condition at time of fall/interview†
Medications taken within 24 hours prior to the fall/interview†
History of falls†
Fall risk level (assigned by nurse at admission)†
Fall prevention strategies in place at time of fall/interview*
Activity level at time of fall/interview§
Normal use of call light for activity§
Side rail and bed position*§
Floor type§
Patient footwear§
Patient-to-nurse ratio of nurse caring for patient at time of fall/interview‖
(if applicable, information on the following)
Bathroom§
Exit alarm§
Restraint ordered and/or in place*
Bedside commode§
Foley catheter†
Intravenous line†
Additional variables collected only for patients who fell
Date/time of fall*
Location of fall*
Discovery type*
Assist type*
Activity trying to perform at time of fall§
Reason for activity§
Fall type§
Primary reason for fall§
Call light use prior to fall*
Furniture/equipment/assistive device involved in the fall§
Type of injury*
Severity of injury*

**Variables contained in the hospital's adverse event reporting system (patients who fell) or patient's electronic chart (controls).*
†Variables contained in the patient's electronic chart.
‡Gait deficit, balance deficit, use of assistive device (hospital and home), cognitive impairment, impaired memory, visually impaired, orthostatic hypotension, urinary/stool frequency and/or incontinence, osteoporosis, lower extremity problems, diabetes, depression, history of stroke, or receiving physical/occupational therapy.
§Variables obtained by either talking with the patient, family member, nurse, observing the environment, or by extracting information from the narrative description of the fall in the adverse event reporting system.
‖Obtained from nurse staffing records.

The electronic nursing charting system or the patient's paper chart was consulted for all cases and controls and provided information on heath status, medical history, medications, fall risk level, and fall prevention measures before the fall/interview. For example, a patient was considered confused if the nurse documented the patient as not being alert to person, place, and time at the time of their fall. The environment of the patient was also assessed by inspecting the patient's room and fall location (if applicable). Staffing information was obtained from nurse staffing records.

Immediately following receipt of fall reports, the nursing electronic charting system and the adverse event report were consulted to identify injuries resulting from the fall. Several weeks after the falls, X-ray and CT scan results were reviewed to identify any fall-related injuries that were not apparent during the initial data collection phase. The types of injuries were then classified into the following categories based on the scale used in the hospital's adverse event reporting system: no injury; minor injury (minor cuts, minor bleeding skin abrasions, swelling, pain, minor contusions); moderate injury (excessive bleeding, lacerations requiring sutures, temporary loss of consciousness, moderate head trauma); and severe injury (fractures, subdural hematomas, other major head trauma, cardiac arrest, death).

Statistical Analysis

Data were double-entered into Microsoft Access (Redmond, WA), cleaned, and transferred to SPSS Version 11.0 (SPSS Inc., Chicago, IL) for analysis. Pearson's χ^2 and Fisher's exact tests were used to compare characteristics of the patients and circumstances of the falls for categorical variables. To compare continuous variables across hospital services, ANOVA and the Kruskal-Wallis test were used as appropriate. The magnitude of the associations between potential risk factors and falling was quantified with the use of the odds ratio. Logistic regression was used to calculate both crude odds ratios (cOR) and adjusted odds ratios (aOR) with 95% confidence intervals (CI). The multivariate model was constructed using a manual stepwise method. Candidate variables were those that were significant or borderline significant in crude analysis. Two-way interactions were assessed to test for effect modification. Cases and controls with missing data were excluded from multivariate analysis. Outliers and influential observations were identified by the use of regression diagnostics. Adequacy of the multivariate model was assessed using the Hosmer-Lemeshow goodness of fit test and the area under the receiver operating characteristic (ROC) curve (c-statistic).

Table 2. Circumstances of First Falls (*N*=98)

Descriptors	*n* (%)
Location	
Patient room	80 (81.6)
Patient bathroom	12 (12.2)
Hallway	4 (4.1)
Other*	2 (2.0)
Time of day	
7:00 AM–6:59 PM	43 (43.9)
7:00 PM–6:59 AM	55 (56.1)
How patient fall was discovered	
Someone found patient down on the floor	64 (65.3)
Witness saw patient fall	27 (27.6)
Self-reported by patient	7 (7.1)
Assist type at time of fall	
Unassisted	83 (84.7)
Assist in use at time of fall	14 (14.3)
Unknown	1 (1.0)
Activity at time of fall	
Ambulating	45 (45.9)
Getting in/out of bed	18 (18.4)
Sleeping/repositioning in bed	6 (6.1)
Standing or sitting (not trying other actions)	7 (7.1)
Trying to sit down	4 (4.1)
Trying to stand up	4 (4.1)
Using toilet	4 (4.1)
Using bathtub	1 (1.0)
Other†	1 (1.0)
Unknown	8 (8.2)
Fall type	
Slid to floor	68 (69.4)
Collapsed	14 (14.3)
Fell from height	9 (9.2)
Unknown	7 (7.1)
Primary reason for fall	
Muscle weakness	35 (35.7)
Dizziness/fainted	12 (12.2)
Slipped	9 (9.2)
Asleep/sedated	7 (7.1)
Lost balance	4 (4.1)
Hip/leg/knee gave out	3 (3.1)
Tripped	2 (2.0)
Other‡	4 (4.1)
Unknown	22 (22.4)
Toileting-related reason for activity§	
Yes	46 (46.9)
No	41 (41.8)
Unknown	11 (11.2)

Nurses' station (1), public bathroom (1).
†*Trying to put feet up in recliner.*
‡*Disoriented (3), intentional fall (1).*
§*Defined as fall occurring during activity involving toileting needs (e.g., ambulating to or from the bathroom, reaching for toilet tissue from the bedside commode).*

RESULTS

Circumstances of Falls

Although we reported on similar fall circumstances in our previous study of patient falls, we report on these factors here as well because variables collected for this study had fewer missing data than our first study.[19] Therefore, this study provides more accurate estimates of fall circumstances (Table 2).

Environmental Circumstances. Of the 98 first falls during the study period, a large majority (82%) occurred in the patient's room, while only 12% occurred in the patient's bathroom. Patients who were confused or disoriented were more likely to fall in an area other than the patient bedroom compared to alert patients (13/49, 27% vs 5/49, 10%; P=.037).

Assistance. Eighty-five percent of patients were not assisted by a person or assistive device at the time of the fall. In fact, 62 of the 73 (85%) patients whose activity level was ordered as "up only with assistance of nursing personnel" were not using assistance when they fell. Only 21 of 50 (42%) of cases who used an assistive device at home actually used one in the hospital, while 39 of 73 (53%) controls who used an assistive device at home actually used one in the hospital. Three quarters of the patients did not use the call light prior to their fall, with the most common reason being they felt they did not need assist-

ance (51%). Patients who did not use the call light before the fall were more likely to be confused or disoriented than those who used the call light (37/74, 50% vs 1/8, 13%; P=.046).

Patient Activity at Time of Fall. Nearly half of the patients were ambulating when they fell, and 18% were getting in or out of bed. Toileting needs were a common reason for the patient's activity at the time of the fall (47%). More toileting-related falls occurred overnight than non-toileting-related falls (31/46, 67% vs 18/41, 44%; P=.027). Only 8 (17%) of toileting-related falls occurred in the bathroom.

Fall-related Injuries

Approximately 37% (36/98) of first falls resulted in some type of injury, including minor (32/98, 33%) and moderate to severe (4/98, 4%) injuries. Minor injuries included pain/swelling (13), abrasions/skin tears (10), bleeding (4), lacerations/perforations/punctures (3), minor contusion (1), and reddened area on skin (1). Moderate injuries included one moderate contusion/hematoma and one neck sprain. Severe injuries included one frontal lobe contusion with acute hemorrhage and one intertrochanteric fracture of the femur. When comparing no injury to any type of injury, some significant associations were identified. Patients who fell in the patient's bathroom were more likely to suffer an injury than those who fell in the patient's hospital room (cOR, 3.9; 95% CI, 1.1 to 14.2). The only patient characteristic significantly associated with suffering an injury was having a visual impairment (cOR, 2.5; 95% CI, 1.1 to 6.0).

Univariate Analysis of Risk Factors for Falling

Several patient-related characteristics were significantly associated with falling in the hospital in univariate analysis (Table 3). As age increased, the risk of falling increased (χ^2 for linear trend, 7.04; P=.008). The largest health status risk factor for falling was having a gait/balance deficit or a lower extremity problem (i.e., pain, swelling, weakness, arthritis, or other problems of the lower extremities; cOR, 9.4; 95% CI, 4.0 to 22.1). Other health status factors significantly associated with falling were urinary or stool frequency or incontinence (cOR, 3.3; 95% CI, 2.1 to 5.3) and having fallen in or out of the hospital within the past 6 months (cOR, 3.4; 95% CI, 2.1 to 5.7). Several mental health status variables were also significantly associated with falling, the most significant of which were impaired memory (cOR, 3.6; 95% CI, 2.2 to 5.8), being agitated (cOR, 3.1; 95% CI, 1.4 to 6.8), and confusion (cOR, 2.9; 95% CI, 1.8 to 4.7). Some medications administered within 24 hours prior to the fall or interview (for controls) were associated with falling (Table 4), including sedatives/hypnotics (cOR, 2.1; 95% CI, 1.2 to 3.7), antiarrhythmic agents (cOR, 2.1; 95% CI, 1.2 to 3.7), diabetes medications (cOR, 2.1; CI, 1.2 to 3.5), and nonnarcotic analgesics (cOR, 2.0; CI, 1.3 to 3.2).

Patient care-related variables were associated with falling in univariate analysis (Table 5). Patients who reported using the call light "only sometimes" were more likely to fall than patients who reported "always" using it (cOR, 3.1; 95% CI, 1.5 to 6.5). Patients who were ordered "up with assist" were 11 times more likely to fall than those assigned "bedrest" (95% CI, 5.2 to 23.1) and 5.7 times more likely to fall than those patients given bathroom privileges (95% CI, 3.0 to 10.9). Increasing patient-to-nurse ratio was associated with an increased

Table 3. Univariate Analysis of Patient-related Characteristics

Patient Characteristic	Patients Who Fell N=98 n (%)	Controls N=318 n (%)	cOR (95% CI)
Patient demographics			
Gender			
Male	44 (44.9)	148 (46.5)	1.0 . . .
Female	54 (55.1)	170 (53.5)	1.1 (0.7 to 1.7)
Age			
< 50	23 (23.5)	120 (37.7)	1.0 . . .
50–69	37 (37.8)	108 (34.0)	1.8 (1.0 to 3.2)
≥70	38 (38.8)	90 (28.3)	2.2 (1.2 to 4.0)
Body mass index			
Normal	36 (36.7)	96 (30.2)	1.0 . . .
Underweight	3 (3.1)	10 (3.1)	0.8 (0.2 to 3.1)
Overweight	23 (23.5)	97 (30.5)	0.6 (0.3 to 1.1)
Obese	27 (27.6)	97 (30.5)	0.7 (0.4 to 1.3)
Unknown	9 (9.2)	18 (5.7)	
Patient health status			
Patient type (acuity)*			
1–2	25 (25.5)	86 (27.0)	1.0 . . .
3–4	47 (48.0)	170 (53.5)	1.0 (0.5 to 1.6)
5–6	14 (14.0)	42 (13.2)	1.1 (0.5 to 2.4)
Unknown	12 (12.2)	20 (6.3)	
Gait/balance deficit or lower extremity problem			
No	6 (6.1)	121 (38.1)	1.0 . . .
Yes	92 (93.9)	197 (61.9)	9.4 (4.0 to 22.1)
Visual impairment			
No	61 (62.2)	229 (72.0)	1.0 . . .
Yes	35 (35.7)	86 (27.0)	1.5 (0.9 to 2.5)
Unknown	2 (2.0)	3 (1.0)	
Orthostatic hypotension			
No	50 (51.0)	243 (76.4)	1.0 . . .
Yes	16 (16.3)	60 (18.9)	1.3 (0.7 to 2.4)
Unknown	32 (32.7)	15 (4.7)	
Urinary/stool frequency, incontinence			
No	48 (49.0)	242 (76.1)	1.0 . . .
Yes	50 (51.0)	76 (23.9)	3.3 (2.1 to 5.3)
Diabetes			
No	60 (61.2)	229 (72.0)	1.0 . . .
Yes	38 (38.8)	89 (28.0)	1.6 (1.0 to 2.6)
Stroke			
No	83 (84.7)	273 (85.8)	1.0 . . .
Yes	14 (14.3)	43 (13.5)	1.1 (0.6 to 2.1)
Unknown	1 (1.0)	2 (0.6)	
Fallen in past 6 months			
No	34 (34.7)	213 (67.0)	1.0 . . .
Yes	49 (50.0)	89 (28.0)	3.4 (2.1 to 5.7)
Unknown	15 (15.3)	16 (5.0)	
Patient mental health status			
Depressed			
No	48 (49.0)	196 (61.6)	1.0 . . .
Yes	46 (47.0)	116 (36.5)	1.6 (1.02 to 2.6)
Unknown	4 (4.1)	6 (1.9)	
Impaired memory			
No	34 (34.7)	209 (65.7)	1.0 . . .
Yes	63 (64.3)	107 (33.6)	3.6 (2.2 to 5.8)
Unknown	1 (1.0)	2 (0.6)	
Orientation			
Alert and oriented to person, place, time	49 (50.0)	230 (72.3)	1.0 . . .
Confused	47 (48.0)	76 (23.9)	2.9 (1.8 to 4.7)
Unconscious	2 (2.0)	12 (3.8)	0.8 (0.2 to 3.6)
Agitated/uncooperative			
No	84 (85.7)	302 (95.0)	1.0 . . .
Yes	13 (13.3)	15 (4.7)	3.1 (1.4 to 6.8)
Unknown	1 (1.0)	1 (0.3)	
Sedated			
No	89 (90.8)	288 (90.6)	1.0 . . .
Yes	9 (9.2)	30 (9.4)	1.0 (0.4 to 2.1)

*Based on complexity of medical care needed by the patient; ranges from 1 to 6, with 1 being the least complex medical care and 6 being the most complex medical care.
cOR; crude odds ratio; CI, confidence interval.

Table 4. Univariate Analysis of Medications Administered to Cases and Controls 24 Hours Prior to Fall or Interview (Controls)

Medication Category	Falls *N*=98 *n* (%)	Controls *N*=318 *n* (%)	cOR (95% CI)
Sedatives/hypnotics	27 (27.6)	48 (15.1)	2.1 (1.2 to 3.7)
Antiarrhythmic agents	22 (22.4)	39 (12.3)	2.1 (1.2 to 3.7)
Antidiabetic agents	29 (29.6)	54 (17.0)	2.1 (1.2 to 3.5)
Nonnarcotic analgesics	46 (46.9)	98 (30.8)	2.0 (1.3 to 3.2)
Miscellaneous CNS-acting agents	18 (18.4)	36 (11.3)	1.7 (0.9 to 3.3)
Anticoagulants	43 (43.9)	105 (33.0)	1.6 (0.99 to 2.5)
Vasodilators/vasoactive	22 (22.4)	32 (10.1)	1.6 (0.9 to 2.8)
Anticonvulsants	15 (15.3)	36 (11.3)	1.4 (0.7 to 2.7)
Antidepressants	23 (23.5)	60 (18.9)	1.3 (0.8 to 2.3)
Benzodiazepines	23 (23.5)	62 (19.5)	1.3 (0.7 to 2.2)
ACE inhibitors	25 (25.5)	71 (22.3)	1.2 (0.7 to 2.0)
Beta blockers	26 (26.5)	77 (24.2)	1.1 (0.7 to 1.9)
Narcotic analgesics	38 (38.8)	116 (36.5)	1.1 (0.7 to 1.8)
Diuretics	22 (22.4)	80 (25.2)	0.9 (0.5 to 1.5)
Antipsychotics	7 (7.1)	28 (8.8)	0.8 (0.3 to 1.9)
Calcium channel blockers	9 (9.2)	47 (14.8)	0.6 (0.3 to 1.2)
Chemotherapy	1 (1.0)	6 (1.9)	0.5 (0.1 to 4.5)

cOR, crude odds ratio; CI, confidence interval; CNS, central nervous system; ACE, angiotensin-converting enzyme.

risk of falling (cOR, 1.6; 95% CI, 1.3 to 1.9). Therefore, the more patients a nurse had to care for, the more likely a patient of that nurse was to fall. A patient whose nurse had more than 5 patients to care for (median=5) was 2.6 times more likely to fall than a patient whose nurse had 5 or fewer patients (95% CI, 1.6 to 4.1). When examined in more detail by categorizing, there was a positive dose-response relationship between patient-to-nurse ratio and the likelihood of falling (χ^2 for linear trend, 28.6; $P<.001$). We also examined the possible association between hospital service and falling, but no significant association was found ($P=.772$).

Regarding prevention strategies, having 1 or more bed rails raised decreased the risk of falling (cOR, 0.02; 95% CI, 0.01 to 0.05). When separated into categories, having 1 to 2 bed rails raised was just as protective as having 3 to 4 rails raised (for both, cOR, 0.02; 95% CI, 0.01 to 0.05). Having all 4 side rails elevated is now considered a restraint and discouraged as a fall prevention strategy at this and many hospitals. Having a visitor present was the only other strategy associated with a lower risk of falling (cOR, 0.3; 95% CI, 0.1 to 0.6).

Multivariate Analysis of Risk Factors for Falling

A multivariate model was built with patient-related, medication, or care-related risk factors (Table 6). The 6 predictors that remained significantly associated with an increased risk of falling were gait/balance impairment or lower extremity problem (aOR, 9.0; 95% CI, 2.0 to 41.0), confusion (aOR, 3.6; 95% CI, 1.6 to 8.4), use of sedatives/hypnotics (aOR, 4.3; 95% CI, 1.6 to 11.5), use of diabetes medications (aOR, 3.2; 95% CI, 1.3 to 7.9), activity level of "up with assistance" compared to "bathroom privileges" (aOR, 8.7; 95% CI, 2.3 to 32.7), and increasing patient-to-nurse ratio (aOR, 1.6; 95% CI, 1.2 to 2.0). When comparing to ≤ 3 patients per nurse, the dose-response effect for patient-to-nurse ratio was still present (4–6 patients: aOR, 2.9; 95% CI, 0.84 to 10.2; ≥ 7 patients: aOR, 7.1; 95% CI, 1.5 to 34.2). Urinary/stool frequency/incontinence was of borderline significance (aOR, 2.3; 95% CI, 0.99 to 5.6). Finally, having 1 or more bed rails raised was protective of falling (aOR, 0.006; 95% CI, 0.001 to 0.024). No biologically plausible interactions among the covariates were found. The model had good discrimination (c-statistic, 0.95) and goodness of fit (Hosmer-Lemeshow statistic, 10.9; $P=.206$).

Table 5. Univariate Analysis of Patient Care-related Factors

Care-related Factor	Falls *N*=98 *n* (%)	Controls *N*=318 *n* (%)	COR (95% CI)
Call light usage			
Always	11 (11.2)	87 (27.4)	1.0 . . .
Sometimes	44 (44.9)	110 (34.6)	3.1 (1.5 to 6.5)
Never	18 (18.4)	86 (27.0)	1.7 (0.7 to 3.7)
Unknown	25 (25.5)	35 (11.0)	
Assigned activity level			
Bathroom privileges	14 (14.3)	99 (31.1)	1.0 . . .
Up with assistance	73 (74.5)	90 (28.3)	5.7 (3.0 to 10.9)
Bedrest	9 (9.2)	122 (38.4)	0.5 (0.2 to 1.3)
Unknown	2 (2.0)	7 (2.2)	
Patient-to-nurse ratio			
≤ 3	6 (6.1)	66 (20.8)	1.0 . . .
4–6	63 (64.3)	221 (69.5)	3.1 (1.3 to 7.6)
≥ 7	24 (24.5)	21 (6.6)	12.6 (4.5 to 34.9)
Unknown	5 (5.1)	10 (3.1)	
Floor type			
Vinyl	83 (84.7)	280 (88.1)	1.0 . . .
Tile	10 (10.2)	29 (9.1)	1.1 (0.5 to 2.5)
Other	2 (2.0)	8 (2.5)	0.8 (0.2 to 4.0)
Unknown	3 (3.1)	1 (0.3)	
Footwear			
Hospital socks	41 (41.8)	185 (58.2)	1.0 . . .
Personal socks	4 (4.1)	23 (7.2)	0.8 (0.3 to 2.4)
Slippers	11 (11.2)	23 (7.2)	2.2 (1.0 to 4.8)
Barefoot	9 (9.2)	56 (17.6)	0.7 (0.3 to 1.6)
Other	2 (2.0)	21 (6.6)	0.4 (0.1 to 1.9)
Unknown	31 (31.6)	10 (3.1)	
Fall prevention strategies			
Bed rails			
0 rails raised	55 (56.1)	8 (2.5)	1.0 . . .
1–2 rails raised	36 (36.7)	252 (79.2)	0.02 (0.01 to 0.05)
3–4 rails raised	7 (7.1)	58 (18.2)	0.02 (0.01 to 0.05)
Visitor present	8 (8.2)	73 (23.0)	0.3 (0.1 to 0.6)
Bedside commode	28 (28.9)	44 (13.8)	2.5 (1.5 to 4.3)
Bed exit alarm	10 (10.2)	18 (5.7)	1.9 (0.8 to 4.2)
Special room*	16 (16.3)	20 (6.3)	2.9 (1.4 to 5.9)
Soft touch call light	2 (2.0)	23 (7.2)	0.3 (0.1 to 1.2)
Toileting schedule	13 (3.3)	3 (0.9)	16.0 (4.5 to 57.5)
Restraints	3 (3.1)	14 (4.4)	0.7 (0.2 to 2.4)
Sitter	2 (2.0)	4 (1.3)	1.6 (0.3 to 9.1)
Special bed (low-boy)	2 (2.0)	2 (0.6)	3.3 (0.5 to 23.7)

**Close to nurses' station or with video surveillance.*
cOR, crude odds ratio; CI, confidence interval.

Analysis Without Psychiatry Patients

We also analyzed the data excluding psychiatry patients (10 cases and 32 controls) because falls of psychiatry patients are qualitatively different from those of other patients (e.g., psychiatric patients sometimes fall intentionally). Variables that became significant in crude analysis were the use of antipsychotics (cOR, 3.4; 95% CI, 1.1 to 10.9) and anticoagulants (cOR, 1.7; 95% CI, 1.1 to 2.8). The variables included in the multivariate model remained the same as presented in Table 6. However, the risk associated with gait/balance deficit or lower extremity problem decreased somewhat and became borderline significant (aOR, 5.8; 95% CI, 0.98 to 34.7).

Table 6. Multivariate Model of Patient-related, Medication, and Care-related Risk Factors Associated with Falling in the Hospital (*N*=92 Cases and 302 Controls)

Factor	aOR	95% CI
Patient-related characteristics		
Gait/balance deficit or lower extremity problem	9.0	2.0 to 41.0
Orientation		
Alert and oriented to person, place, time	—	—
Confused	3.6	1.6 to 8.4
Unconscious	12.4	0.99 to 154.9
Urinary/stool frequency/incontinence	2.3	0.99 to 5.6
Medications		
Sedatives/hypnotics	4.3	1.6 to 11.5
Diabetes medications	3.2	1.3 to 7.9
Care-related factors		
Activity level		
Bathroom privileges	—	—
Up with assistance	8.7	2.3 to 32.7
Bedrest	0.4	0.1 to 2.1
Increasing patient-to-nurse ratio	1.6	1.2 to 2.0
One or more bed rails raised	0.006	0.001 to 0.024

aOR, adjusted risk ratio; CI, confidence interval.

DISCUSSION

Hospital falls have a multifactorial etiology. Our study suggests that specific health and mental health status variables (i.e., gait or lower extremity problems, urinary/stool frequency/incontinence, and confusion) as well as use of certain medications (i.e., sedatives/hypnotics or diabetes medications) increase the likelihood that the patient will fall. Furthermore, the circumstances of patient falls are quite patterned, many occurring unassisted, while the patient is ambulating or getting out of bed, and related to toileting needs. Environmental or care-related factors were also associated with falling. The more patients a nurse was caring for, the more likely it was that a patient would fall. Having bed rails raised had a negative association with falling.

Many of our findings regarding patient-related risk factors for falling are confirmatory of prior studies, such as gait or balance deficit or lower extremity problems,[12,17,18,21,22] confusion,[10,12,17,18,21,22] and urinary or stool frequency or incontinence.[12,17] The use of sedatives/hypnotics has been documented as a risk factor for falling in the hospital in another study[10] and as a risk factor for injurious falls in the nursing home.[23] The condition of diabetes has been linked with falling,[24] while use of diabetes medications (i.e., rosiglitazone maleate, glimepiride, glipizide, glyburide, insulin, and pioglitazone) was a risk factor in our study. A potential hypothesis for this association could be that diabetes medications may increase the risk of falling by causing hypoglycemia, or may simply be a marker of complications of diabetes, such as peripheral neuropathy or polyuria.

The environmental or care-related variables found to be associated with falling in this study are more novel findings. Recent studies have highlighted associations between nurse staffing levels and adverse outcomes,[25,26] including patient falls. More licensed nurses, higher proportions of registered nurse care, and increased registered nurse hours worked per patient day have been significantly associated with lower fall rates in a few small studies.[27–29] These studies examined the link at the hospital or unit level. To our knowledge, ours is the first study to find a significant association between falling and nurse staffing at the individual level using patient-to-nurse ratios. The dose-response relationship observed also helps to support causality of the relationship.

The Joint Commission on Accreditation of Healthcare Organizations and the U.S. Food and Drug Administration have issued alerts and recommendations regarding bed rails in response to reports of entrapment, injury, and death associated with their use.[30,31] While the use of bed rails has been associated with serious injuries and even death,[32,33] our study shows that their use can also help prevent falls. (Low numbers of serious injuries precluded us from determining whether side rails were associated with serious injury.) Our findings are contrary to a nursing home study that found that bilateral side rail use did not decrease the risk of falls.[34] However, their comparison group was having no or 1 side rail raised, while ours was having no rails raised. It is also interesting to note that our study showed that having 1 to 2 bed rails raised is just as effective in reducing the risk of falling as having 3 to 4 rails raised. Although hospitals are decreasing bed rail use, its effect on fall rates has not been well documented. One study observed no significant change in fall rate in a rehabilitation unit for older patients when bed rail use was reduced, but did observe a nonsignificant trend in the direction of an increase in the fall rate.[35] There is a need for carefully controlled intervention studies to determine the impact of side rail use on fall rates and their association with injury.

It is important to remark on some of the differences observed in crude analysis after excluding psychiatry patients. In crude analysis, antipsychotics became significant because most controls that were on these medications were psychiatry patients. The use of psychoactive drugs or antipsychotics has been associated with falling in previous hospital and nursing home studies.[21,23,36] The distinctive characteristics of psychiatry patients, such as different medications and different reasons for falling (e.g., falling intentionally), may warrant separate examination from the rest of the hospital population.

There were several limitations to our study that should be considered when interpreting our results. Falls were reported via a voluntary reporting system, so we may not have examined all falls that occurred during the study period. The accuracy of fall reports, and consequently fall rates, based on the online reporting system is unknown. Data collectors were not blinded to patients' fall status. Some of the variables collected were not objectively measured. Collecting data from different sources also introduced bias. We could not interview all patients and nurses, causing us to rely only on medical record data for some patients. Data collectors were more likely to interview nurses for the cases and to interview patients for the controls due to poorer health status of the cases. Upon post-hoc analysis comparing crude odds ratios using the patient or family as the primary source of data versus the health care worker as the primary source of data, only 1 variable differed markedly in crude odds ratio (history of fainting/syncope) and was thus dropped from all analyses. Crude odds ratios for some variables, such as gait or balance deficit, were slightly larger when based on patient- or family-reported data, but remained in analyses. Because data collectors were more likely to interview nurses for cases and patients for controls, this differential source of data most likely did not inflate the odds ratios. Recall bias could have been a factor during the interviews. Data collected from interviews with patients who were confused or

disoriented may not be reliable. Small sample size prevented the estimation of accurate odds ratios. Finally, a retrospective case-control study design that includes interviewing patients or nurses after a fall could result in cases searching for a cause for the fall, causing odds ratios for some variables to be greater than the true odds ratios. Considering these limitations, the magnitude of some of the associations found could be inflated, but the extensive literature supporting our findings indicates that the risk factors found are true risk factors for falling.

Fall prevention strategies should be linked to the patient characteristics that lead a patient to fall and the circumstances surrounding these falls. Therefore, based on our results, strategies should focus on providing frequently scheduled mobilization or assistance for those with gait or balance problems or lower extremity problems. Strategies to study also include use of toileting schedules for patients with incontinence, and monitoring and adjusting the use of medications related to falling. Future research needs to further examine the link between environmental factors such as nurse staffing levels or bed rail use and falling suggested by our study, as well as methods to address these complex issues.

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