HHS Public Access
Author manuscript
J Patient Saf. Author manuscript; available in PMC 2019 March 01.

Published in final edited form as:
J Patient Saf. 2018 March ; 14(1): 27–33. doi:10.1097/PTS.0000000000000163.

Medications and Patient Characteristics Associated with Falling in the Hospital

Caroline A. O'Neil, MA, MPH[1], **Melissa J. Krauss, MPH**[2], **Jon Bettale, BSN, MBA**[3], **Anthony Kessels, PharmD**[3], **Eileen Costantinou, MSN**[3], **W. Claiborne Dunagan, MD**[1,4], and **Victoria J. Fraser, MD**[1]

[1]Washington University School of Medicine, Division of Infectious Diseases, St. Louis, MO, USA

[2]Washington University School of Medicine, Department of Psychiatry, St. Louis, MO, USA

[3]Barnes-Jewish Hospital, St. Louis, MO, USA

[4]BJC Health Care, St. Louis, MO, USA

Abstract

Objectives—To evaluate specific medications and patient characteristics as risk factors for falling in the hospital.

Methods—Case-control study comparing demographic, health, mobility, and medication data for 228 patients who fell between 6/29/2007 and 11/14/2007 at a large tertiary care hospital and 690 randomly-selected control patients. Logistic regression was used to identify fall risk factors.

Results—Independent risk factors for falling included: history of falls (OR, 2.7; 95% CI, 1.8 – 4.2); needing an assistive device (OR, 3.2; 95% CI, 1.5 – 6.8) or person assistance (OR, 2.1; 95% CI, 1.3 – 3.3) to ambulate; being underweight (OR, 2.4; 95% CI, 1.2 – 4.7) or obese (OR, 1.6; 95% CI, 1.0 – 2.5); confusion (OR, 2.4; 95% CI, 1.5 – 4.0); dizziness (OR, 2.1; 95% CI, 1.1 – 4.3); incontinence (OR, 1.5; 95% CI, 1.0 – 2.3); and an order for a hydantoin (OR, 3.3; 95% CI, 1.3 – 8.0) or benzodiazepine anticonvulsant (OR, 2.2; 95% CI, 1.5 – 3.3), haloperidol (OR, 2.8; 95% CI, 1.2 – 6.8), tricyclic antidepressant (OR, 2.4; 95% CI, 1.2 – 4.9) or insulin (OR, 1.5; 95% CI, 1.0 – 2.1). Female gender (OR, 0.8; 95% CI, 0.6–1.0), proton pump inhibitors (OR, 0.6; 95% CI, 0.4 – 0.9), and muscle relaxants (OR, 0.4; 95% CI, 0.3 – 0.7) were associated with lower risk of falling.

Conclusions—This study identified medications and patient characteristics associated with increased risk for falling in the hospital. High-risk medications identified in this study may serve as targets for medication review or adjustment, which have been recommended as a component of multifaceted fall prevention programs.

Address for Correspondence and reprints: Caroline O'Neil, Washington University School of Medicine, Department of Internal Medicine, Division of Infectious Diseases, Campus Box 8051, 660 South Euclid Avenue, St. Louis, MO 63110, Phone: (314) 454-8219, Fax: (314) 454-8279, coneil@dom.wustl.edu.

Conflicts of Interest: The authors have declared no conflicts of interest.

INTRODUCTION

Falls are common adverse events in hospitals and can result in significant injuries. Reported fall rates for hospital inpatients range from 1.7 to 25 falls per 1,000 patient days, depending on the patient care area, with 6%–44% resulting in injury[1]. Injurious falls are associated with increased healthcare costs, longer hospital stays, and greater likelihood of discharge to a nursing home or rehabilitation facility[2, 3]. Medication review has been recommended as part of multifaceted fall prevention programs for hospital inpatients[4, 5]. However, guidelines for how to assess medication risk or specifying which medications should be targeted are limited.

Several medications have been reported to increase the risk for falling in the hospital, most commonly sedatives/hypnotics, benzodiazepines, and psychotropics[6–8]. Other medications, including antiepileptics, anticholinergics, beta blockers, and antidiabetic agents, have been inconsistently associated with fall risk[6, 9]. Although prior studies have evaluated medications as risk factors for falling, most have focused on broad medication classes rather than specific types of drugs and few studies have evaluated the effect of newly prescribed versus long term medications on fall risk. This lack of detail makes it difficult to develop an effective, comprehensive, and predictive view of a patient's fall risk and hinders the development of medication review interventions, which are a recommended part of comprehensive fall prevention strategies.

To provide more detailed information about the association between medications and falling in the hospital, we conducted a case-control study of patients who fell at a large teaching hospital. The objective of this study was to identify specific medications and patient demographic and health characteristics associated with falls and to evaluate the impact of multiple high-risk medications and newly prescribed medications on fall risk.

METHODS

Study Population

This study was conducted at Barnes-Jewish Hospital (BJH), a 1,074-bed urban tertiary care hospital affiliated with Washington University School of Medicine. In 2007, BJH had 1,036 reported falls and a fall rate of 3.50 per 1,000 patient days. The study included all inpatient falls reported to the hospital's safety event reporting system between June 29 and November 14, 2007.

The BJH safety event reporting system defines a fall as a sudden and unplanned descent from a standing, sitting, or horizontal position to the floor or an extension of the floor. This definition includes falls related to physiologic events and falls in which the patient is assisted to the floor by staff or a visitor. Inpatients age 21 and older admitted to medicine, surgery, step down, and critical care services were eligible for inclusion in this study. Patients in the emergency room or on the obstetrics service were excluded because risk factors for falls in these units differ from risk factors for falls among the general hospital population. Oncology and psychiatry patients were excluded due to their unique comorbidities and medications which may impact fall risk. Falls that occurred during physical therapy sessions were excluded because these sessions encourage activities that can cause postural instability and may result in the patient being lowered to the floor by a physical therapist to prevent injury.

Two hundred and fifty fall events were prospectively identified for inclusion in the study using fall safety event reports. Fall reports were cross-referenced to identify patients who fell multiple times during their admission; only the first falls were included in the analysis[10]. For each patient who fell, three control patients who were in the hospital during the same period of time but did not fall were identified using the hospital's informatics database. Controls were randomly selected from among patients who were admitted within three days of the index case and discharged after the date of the fall. For six cases with particularly long admissions, controls meeting these criteria could not be identified and patients admitted more than three days after the case patient were selected.

The study protocol was reviewed and approved by the Washington University Human Research Protection Office. The need for written informed consent was waived because the study used preexisting data and posed no additional risk to patients.

Data Sources

Patient demographic data, including age, gender, and body mass index (BMI) was obtained from the hospital informatics database. Data on history of falls, mobility, ability to estimate the time (a measure of confusion), whether the patient overestimated his/her abilities (based on nurse observations), urinary/stool frequency or incontinence, and presence of neuropathy, syncope/fainting, or dizziness/orthostatic hypotension prior to the fall were abstracted from electronic medical records. Details about fall events, including fall location, whether the fall was assisted, and any resulting injuries, were collected from fall safety event reports. Data on all active medication orders from the four days prior to the fall were obtained from the hospital pharmacy database. Medications taken prior to admission were identified by comparing hospital drug orders to a list of home medications recorded in the patient's admission assessment according to the Joint Commission's Medication reconciliation guidance for hospitals. Medications were considered "new" if first prescribed during the hospitalization and "continued" if taken prior to admission.

Statistical Analysis

Data abstracted from patient medical records were double-entered into Microsoft Access (Redmond, WA), cleaned, and merged with the data from electronic medical records. All statistical analysis was performed using IBM SPSS Statistics, version 16.0 (IBM Inc., Armonk, NY). Logistic regression was used to calculate crude odds ratios (ORs) and 95% confidence intervals (CIs) for potential fall risk factors. Medications ordered for fewer than five cases or control patients were excluded from the analysis due to low cell counts. A multivariable model was then developed using a manual stepwise method and inputting variables with univariate p-values <0.10. Abnormal gait and having a fall as the reason for admission were not included in the multivariable analysis due to colinearity with ambulation and history of falls, respectively. Patients with missing data for any of the variables included in the multivariable model were also excluded from the multivariable analysis. Variables with a p-value <0.05 in multivariable analysis were retained in the final model. Two-way interaction terms for the medications included in the final model were assessed to test for effect modification. Adequacy of the model was assessed using the Hosmer-Lemeshow goodness of fit test.

Additional analyses were conducted to provide further information about the medications identified as risk factors in the multivariable model. Multivariable analyses were conducted to determine whether patients prescribed multiple high risk medications were at greater risk for falls than others, while controlling for the patient characteristics associated with falls in the multivariable model. Fisher's exact tests were used to determine whether new medication orders were associated with greater risk for falling in the hospital than medications taken prior to admission.

RESULTS

Fall Circumstances and Outcomes

From the 250 fall events reported during the study period, 226 first falls were identified. These cases and the corresponding 678 controls were included in the analysis. Falls were equally distributed during day (48.7%) and night (51.3%) shifts. Although most falls (81.0%) were unassisted, 14.1% of patients who fell were assisted to the floor by an employee and 4.9% were assisted by a visitor. Common fall circumstances included: falls from bed (37.2%); falls while ambulating (23.5%); falls from a standing position (11.9%); falls from a chair (8.0%); and falls from a bedside commode (8.4%) or toilet (4.0%). Only 9.7% of patients who fell had asked for assistance prior to the fall. Environmental hazards that contributed to falls included: rolling equipment (7.5%); having a needed item out of reach (6.2%); inappropriate footwear (4.0%); slippery floors (3.5%); and trip hazards or clutter (1.3%). Approximately 38% of falls were related to the patient's need for toileting.

Of the patients who fell, 161 (71.2%) were not injured. Fifty two patients (23.0%) sustained minor injuries, such as abrasions or bruising, three (1.3%) sustained moderate injury, and three (1.3%) sustained major injury. Moderate injuries included damaged teeth (2 patients) and facial swelling/bleeding. Major injuries included a maxillary sinus fracture, a pelvic fracture, and a subdural hematoma. Mean length of stay was similar for patients who fell (11.3 days) and controls (11.4 days), $p = 0.903$.

Univariate Analysis

Table 1 presents demographic, mobility, and health data for patients who fell and controls. Variables with univariate p-values <0.10 included gender, being underweight (BMI < 18.5 kg/m^2), history of falls during the past three months or as the reason for hospital admission, weak or impaired gait, needing an assistive device or person assistance to ambulate, incontinence, syncope, dizziness, over-estimating ability, and providing an incorrect time estimate (confusion).

Medication data for case and control patients are presented in Table 2. Medications in this table are organized according to the Cerner Multum drug classification system (www.multum.com), which is how drug order data is coded at our institution. The Multum drug classification system organizes medications into categories and subcategories by type.

Certain medications, such as benzodiazepines, may be classified under different categories depending on how they are ordered, although a single medication order can only have one classification to avoid redundancy. The Multum system thus provides information not only about the specific drug that was ordered, but also about its intended application. This allowed for a detailed analysis of the association between specific medications and medication categories and risk for falling in the hospital.

Medications associated with falling ($p < 0.10$) included centrally acting antiadrenergic agents (clonidine and methyldopa), benzodiazepine anticonvulsants (lorazepam, diazepam, clonazepam), hydantoin anticonvulsants (phenytoin), antidiarrheals (loperamide), insulin, tricyclic antidepressants (amitriptyline, nortriptyline, clomipramine, doxepin, desipramine), phenylpiperazine antidepressants, and haloperidol. Antiarrhythmics, potassium-sparing diuretics, vasopressors, narcotic analgesic combinations, NSAIDs, 5HT3 receptor antagonists, anticholinergic antiemetics, anticholinergic antiparkinson agents, 'other' anxiolytics/sedatives (diphenhydramine and zolpidem), general anesthetics, muscle relaxants, antacids, proton pump inhibitors, antihistamines, and decongestants were associated with reduced risk.

Multivariate Analysis

The final multivariable model is presented in Table 3. There were 887 patients included in the final model after data for 17 patients who were missing data for one or more of the included variables were excluded from the analysis. History of falls (aOR, 2.73; 95% CI, 1.79 – 4.16), needing an assistive device (aOR, 3.17; 95% CI, 1.47 – 6.80) or person assistance (aOR, 2.08; 95% CI, 1.31 – 3.31) to ambulate, being underweight (aOR, 2.35; 95% CI, 1.17 – 4.74) or obese (aOR, 1.58; 95% CI, 1.01 – 2.48), confusion/incorrect time estimate (aOR, 2.44; 95% CI, 1.48 – 4.03), dizziness (aOR; 2.12, 95% CI, 1.05 – 4.28), and incontinence, (aOR, 1.53; 95% CI, 1.00 – 2.33) were identified as independent risk factors for falling. Medications associated with increased risk for falling included hydantoin anticonvulsants (aOR, 3.25; 95% CI, 1.33 – 7.95), benzodiazepine anticonvulsants (aOR, 2.19; 95% CI, 1.46 – 3.29), haloperidol (aOR, 2.80; 95% CI, 1.16 – 6.77), tricyclic antidepressants (aOR, 2.43; 95% CI, 1.21 – 4.90) and insulin (aOR, 1.46; 95% CI, 1.01 – 2.13). Female gender (aOR, 0.69, 95% CI, 0.48 – 0.98) and an order for a proton pump inhibitor (aOR, 0.63; 95% CI, 0.44 – 0.90) or muscle relaxant (aOR, 0.44; 95% CI, 0.27 – 0.71) were associated with reduced risk of falling. The Hosmer-Lemeshow goodness of fit test showed adequacy of the model ($p=.574$). No two-way interaction terms for medications included in the final model were statistically significant.

Additional Analyses

Results of the analysis to determine the effect of having orders for more than one of the high-risk medications identified in the multivariable model is presented in Table 4. A dose-response effect was observed between the number of high-risk medications and falls. Patients prescribed two high-risk medications were 3.4 times more likely to fall during their hospital stay than patients on no high risk medications and patients with orders for three or more high-risk medications were 11.8 times more likely to fall.

In the analysis to determine whether new medication orders were associated with greater risk than medications continued from home, there was no statistical difference in the proportion of new orders for cases versus controls in any of the high-risk medication categories (Fisher's Exact test p-values: 0.48 for haloperidol; 0.61 for benzodiazepine anticonvulsants; and 1.00 for hydantoin anticonvulsants, tricyclic antidepressants, and insulin). However, this analysis may have been limited by potentially incomplete information regarding medications used prior to hospital admission and small numbers.

DISCUSSION

Multiple factors contribute to risk for falling in the hospital, including intrinsic patient risk factors, medications, and environmental hazards. The patient characteristics identified as risk factors in this study are generally consistent with risk factors previously identified in the literature. Female gender was associated with reduced likelihood of falls in our study, consistent with previous studies which have shown that males are at increased risk for falling in the hospital[11–13]. Prior studies have also identified history of falls [6, 7], need for ambulatory assistance[14, 15], confusion[3, 7, 12, 16], dizziness[12, 17] and incontinence [3, 12, 18] as fall risk factors. Although older age is generally considered to be an important fall risk factor[3, 19], age was not associated with falls in our study. However, evidence for an association between older age and falls in acute care settings is inconsistent[1] and may be related to an association between age and physical changes that increase fall risk[20].

We could find no prior studies in the literature that report an association between patient BMI and risk for falling in the hospital. However, studies of community-dwelling adults have identified an association between being underweight or obese and risk for injurious falls[21, 22]. Underweight patients may be at increased risk due to frailty[23, 24]. Obese patients may be at risk if they do not exercise regularly[15], have multiple comorbidities[1, 15, 25], or have difficulty navigating a hospital room. Additional studies are needed to further investigate the association between BMI and fall risk.

Most of the medications identified as risk factors in this study have also been previously identified in the literature. Several studies have reported an association between anticonvulsants and risk for falling in the hospital[6], although few have examined specific types of anticonvulsants in relation to falls. Only hydantoin and benzodiazepine anticonvulsants were identified as independent risk factors for falling in this study. Benzodiazepines are known to be associated with increased risk of falling[26–28] and lorazepam and diazepam have been specifically identified as risk factors for falls in hospital patients[28]; however, only one prior study has reported an association between hydantoins and falls[29]. Antidepressants are also known to increase risk for falling in the hospital[28, 30, 31] and tricyclic antidepressants have been identified as a risk factor for falls in community and nursing home settings[32, 33].

This study is among the first to report an association between haloperidol or insulin and falls. We could find only one study reporting an association between haloperidol and hospital falls[28], although antipsychotics, in general, are a frequently identified risk factor[31]. Prior studies have reported an association between antidiabetic medications and risk for falling in the hospital but have not identified insulin, specifically, as a risk factor[16, 27]. Insulin was the only antidiabetic medication associated with falls in our study, a finding that is supported by a systematic review which found that insulin, but not other antidiabetic medications, increases fall risk[34].

Two types of medications were associated with reduced risk for falling in the multivariable model: proton pump inhibitors (esomeprazole, lansoprazole, omeprazole, pantoprazole, rabeprazole) and muscle relaxants (vercuronium, succinylcholine, rocuronium, cyclobenzaprine, baclofen, and atracurium). An association between proton pump inhibitors and falls has not been previously reported and the reason for this association is unclear. An association between muscle relaxants and falls has also not been reported, but is likely related to the fact that patients taking muscle relaxants are generally sedated or medically paralyzed ICU patients who are relatively immobile and therefore, unlikely to fall.

While an order for a hydantoin anticonvulsant, benzodiazepine anticonvulsant, haloperidol, tricyclic antidepressant, or insulin was associated with increased risk for falling when taken alone, the risk of falling was more pronounced in patients with orders for more than one of these medications. Polypharmacy, especially involving high-risk medications, has been consistently identified as a risk factor for falling in the hospital[6, 9]. These findings suggest that patients with orders for multiple high-risk medications should be placed on fall precautions and alternative medication regimens considered, when possible. Although we found no statistical difference in the proportion of new medication orders for patients who fell versus controls, further study is warranted, as small numbers and potentially incomplete home medication records may have limited this analysis.

Strengths of this study include prospective data collection, detailed evaluation of medications, use of multivariable analysis, and a relatively large sample size. Limitations include the matching of cases and controls only on date of admission and data limitations, including inconsistencies in fall risk assessments, fall reports completed by staff who may not have witnessed the fall, and medication data derived from pharmacy orders rather than drug administration records. As a single institution study, our results may also not be broadly generalizable. Additional studies that make use of more robust data and statistical techniques will be needed to validate the associations identified in this study and to evaluate the impact of patient diagnosis and comorbidity on these associations. Additional research is also needed to identify risk factors for falls in groups excluded in this analysis, such as oncology and psychiatry patients. Large multicenter data sets will be needed to examine infrequently prescribed medications and allow for greater generalizability of study results.

CONCLUSION

This study identified medications and patient characteristics associated with falls in a hospital setting and examined the impact of multiple high-risk medications on risk for falling. The results provide further evidence for an association between certain medications and risk for falling in the hospital, with risk being more pronounced in patients prescribed more than one high-risk medication. Supplementing existing fall risk assessment and prevention tools with medication review targeting these high-risk medications may allow for better identification of patients at risk for falling during their hospital admission and help to reduce the incidence of patient falls. High risk medications should be avoided, when possible, especially for patients who are already at high risk for falls or injury. The accumulating evidence for an association between certain medications and risk for falling, and the importance of falls as a public health and hospital safety problem, also suggests that it may be beneficial to routinely evaluate the potential effect of new medications on fall risk during the drug approval process.

Acknowledgments

Source of Funding: This study was supported by Grant #00808-1106 from the Barnes-Jewish Hospital Foundation, Grant # 5K24AI067794 from the NIH, Grant # 5U01CI0000333 from the CDC, and Grant # 1KL2RR024994 from the NIH and the National Center for Research Resources.

The authors thank Eric W. Werner, MPH and Nhial Tutlam, MPH for their assistance with data collection. We also thank the BJH Patient Falls Reduction Team and BJC HealthCare Falls with Injury Preventable Harm Team for their support for this project.

References

1. Currie, LM. Fall and Injury Prevention. In: Hughes, RG., editor. Patient safety and quality: An evidence-based handbook for nurses. Rockville, MD: Agency for Healthcare Research and Quality; 2008. p. 1-195.p. 191-250.
2. Bates DW, Pruess K, Souney P, et al. Serious falls in hospitalized patients: correlates and resource utilization. Am J Med. 1995; 99(2):137–143. [PubMed: 7625418]
3. Healey, F., Scobie, S. The third report from the Patient Safety Observatory: Slips, trips and falls in hospital. London: National Patient Safety Agency; 2007.
4. Gray-Micelli, D. Preventing falls in acute care. In: Capezuti, E.Zwicker, D.Mezey, M., Fulmer, T., editors. Evidence-based geriatric nursing protocols for best practice. 3. New York: Springer Publishing Company; 2008. p. 161-198.
5. Oliver D, Connelly JB, Victor CR, et al. Strategies to prevent falls and fractures in hospitals and care homes and effect of cognitive impairment: systematic review and meta-analyses. BMJ. 2007; 334:82. [PubMed: 17158580]
6. Evans D, Hodgkinson B, Lambert L, et al. Falls risk factors in the hospital setting: a systematic review. Int J Nurs Pract. 2001; 7(1):38–45. [PubMed: 11811346]
7. Oliver D, Daly F, Martin FC, et al. Risk factors and risk assessment tools for falls in hospital in-patients: a systematic review. Age and Ageing. 2004; 33(2):122–130. [PubMed: 14960426]
8. 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. Jan; 1999 47(1):30–39. [PubMed: 9920227]
9. Leipzig RM, Cumming RG, Tinetti ME. Drugs and falls in older people: a systematic review and meta-analysis: II. Cardiac and analgesic drugs. J Am Geriatr Soc. Jan; 1999 47(1):40–50. [PubMed: 9920228]
10. Gaebler S. Predicting which patient will fall again ... and again. J Adv Nurs. 1993; 18(12):1895–1902. [PubMed: 8132920]
11. Halfon P, Eggli Y, Van Melle G, et al. Risk of falls for hospitalized patients: a predictive model based on routinely available data. J Clin Epidemiol. 2001; 54(12):1258–1266. [PubMed: 11750195]
12. Hendrich AL, Bender PS, Nyhuis A. Validation of the Hendrich II Fall Risk Model: a large concurrent case/control study of hospitalized patients. Appl Nurs Res. 2003; 16(1):9–21. [PubMed: 12624858]
13. Brand CA, Sundararajan V. A 10-year cohort study of the burden and risk of in-hospital falls and fractures using routinely collected hospital data. Qual Saf Health Care. Jun 17.2010 19(6)

14. Ash KL, MacLeod P, Clark L. A case control study of falls in the hospital setting. J Gerontol Nurs. 1998; 24(12):7–15.
15. Stevenson B, Mills EM, Welin L, et al. Falls risk factors in an acute-care setting: a retrospective study. Can J Nurs Res. 1998; 30(1):97–111. [PubMed: 9726185]
16. Krauss MJ, Evanoff B, Hitcho E, et al. A case-control study of patient, medication, and care-related risk factors for inpatient falls. J Gen Intern Med. 2005; 20(2):116–122. [PubMed: 15836543]
17. Beyea SC. Preventing patient falls in perioperative settings. AORN J. Feb; 2005 81(2):393–395. [PubMed: 15768548]
18. Oliver D, Britton M, Seed P, et al. Development and evaluation of evidence based risk assessment tool (STRATIFY) to predict which elderly inpatients will fall: case-control and cohort studies. BMJ. 1997; 315(7115):1049–1053. [PubMed: 9366729]
19. Cozart HC, Cesario SK. Falls aren't us: state of the science. Crit Care Nurs Q. Apr-Jun;2009 32(2): 116–127. [PubMed: 19300076]
20. Wilson EB. Preventing patient falls. AACN Clin Issues. 1998; 9(1):100–108. [PubMed: 9505576]
21. Tinetti ME, Doucette JT, Claus EB. The contribution of predisposing and situational risk factors to serious fall injuries. J Am Geriatr Soc. 1995; 43(11):1207–1213. [PubMed: 7594153]
22. Malmivaara A, Heliovaara M, Knekt P, et al. Risk factors for injurious falls leading to hospitalization or death in a cohort of 19,500 adults. Am J Epidemiol. 1993; 138(6):384–394. [PubMed: 8213744]
23. Ensrud KE, Ewing SK, Cawthon PM, et al. A comparison of frailty indexes for the prediction of falls, disability, fractures, and mortality in older men. J Am Geriatr Soc. Mar; 2009 57(3):492–498. [PubMed: 19245414]
24. Ensrud KE, Ewing SK, Taylor BC, et al. Frailty and risk of falls, fracture, and mortality in older women: the study of osteoporotic fractures. J Gerontol A Biol Sci Med Sci. Jul; 2007 62(7):744–751. [PubMed: 17634322]
25. 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(4):M112–M117. [PubMed: 2738307]
26. Gales BJ, Menard SM. Relationship between the administration of selected medications and falls in hospitalized elderly patients. Annals of Pharmacotherapy. 1995; 29(4):354–358. [PubMed: 7633010]
27. Passaro A, Volpato S, Romagnoni F, et al. Benzodiazepines with different half-life and falling in a hospitalized population: The GIFA study. Gruppo Italiano di Farmacovigilanza nell'Anziano. J Clin Epidemiol. 2000; 53(12):1222–1229. [PubMed: 11146268]
28. Mendelson WB. The use of sedative/hypnotic medication and its correlation with falling down in the hospital. Sleep. 1996; 19(9):698–701. [PubMed: 9122555]
29. Ziere G, Dieleman JP, Hofman A, et al. Polypharmacy and falls in the middle age and elderly population. Br J Clin Pharmacol. Feb; 2006 61(2):218–223. [PubMed: 16433876]
30. Vassallo M, Sharma JC, Allen SC. Characteristics of single fallers and recurrent fallers among hospital in-patients. Gerontology. 2002; 48(3):147–150. [PubMed: 11961367]
31. Angalakuditi MV, Gomes J, Coley KC. Impact of drug use and comorbidities on inhospital falls in patients with chronic kidney disease. Ann Pharmacother. Oct; 2007 41(10):1638–1643. [PubMed: 17785615]
32. French DD, Campbell R, Spehar A, et al. Drugs and falls in community-dwelling older people: a national veterans study. Clin Ther. Apr; 2006 28(4):619–630. [PubMed: 16750473]
33. Thapa PB, Gideon P, Cost TW, et al. Antidepressants and the risk of falls among nursing home residents.[comment]. N Engl J Med. 1998; 339(13):875–882. [PubMed: 9744971]
34. Berlie HD, Garwood CL. Diabetes medications related to an increased risk of falls and fall-related morbidity in the elderly. Ann Pharmacother. Apr; 2010 44(4):712–717. [PubMed: 20215495]

Table 1

Results of the Univariate Analysis of Patient Characteristics as Risk Factors for Falls

Characteristic	Cases n = 226 (%)	Controls n = 678 (%)	OR (95% CI)
Gender (female)	103 (45.6)	355 (52.4)	0.76 (0.56 – 1.03)
Age, mean (SD)	61.5 (15.5)	59.7 (17.4)	1.01 (0.99 – 1.02)
BMI			
Normal (18.5 – 24.9)	61 (26.9)	222 (32.7)	1[Reference]
Underweight (≤18.5)	22 (9.7)	31 (4.6)	**2.58 (1.40 – 4.78)**
Overweight (25.0 – 29.9)	68 (30.1)	197 (29.1)	1.26 (0.85 – 1.87)
Obese (≥30)	73 (32.3)	218 (32.3)	1.22 (0.83 – 1.80)
History of falls	75 (33.2)	76 (11.2)	**3.93 (2.73 – 5.67)**
Fall was reason for admission	15 (6.6)	18 (2.7)	**2.65 (1.31 – 5.34)**
Gait			
Normal	28 (12.4)	186 (27.4)	1[Reference]
Weak or impaired	160 (70.8)	350 (51.6)	**1.49 (1.21 – 1.83)**
Unable to assess	38 (16.8)	142 (20.9)	**1.78 (1.04 – 3.04)**
Ambulation			
No assistance needed	36 (15.9)	230 (33.9)	1[Reference]
Bedrest	43 (19.0)	148 (21.8)	**1.86 (1.14 – 3.03)**
Assistive device	16 (7.1)	34 (5.0)	**3.01 (1.51 – 6.00)**
Person assistance	131 (58.0)	266 (39.2)	**3.15 (2.09 – 4.74)**
Incontinence	61 (27.0)	108 (15.9)	**1.95 (1.36 – 2.79)**
Urinary catheter	77 (34.1)	242 (35.7)	0.93 (0.68 – 1.27)
Hearing impairment[a]	13 (5.8)	29 (4.3)	1.40 (0.71 – 2.75)
Glasses[b]	114 (50.4)	330 (48.7)	1.17 (0.83 – 1.66)
Neuropathy	8 (3.5)	30 (4.4)	0.80 (0.36 – 1.76)
Syncope	14 (6.2)	20 (2.9)	**2.17 (1.08 – 4.38)**
Dizziness	20 (8.8)	29 (4.3)	**2.17 (1.20 – 3.92)**
Overestimates ability	73 (32.3)	99 (14.7)	**2.77 (1.95 – 3.93)**
Estimate of the time (confusion)			
Correct	146 (64.6)	554 (81.7)	1[Reference]
Incorrect	55 (24.3)	52 (7.7)	**4.01 (2.64 – 6.11)**
Unable to answer	25 (10.6)	69 (10.2)	1.32 (0.80 – 2.17)
High risk for falls[c]	143 (63.3)	284 (41.9)	**2.39 (1.75 – 3.26)**

Abbreviations: OR, odds ratio; CI, confidence interval

[a]Data was missing for 42 (18.6%) cases and 116 (17.1%) controls.

[b]Data was missing for 44 (19.5%) cases and 117 (17.3%) controls.

[c]Risk determined by a nursing falls risk assessment that evaluated history of falls, weak or impaired gait, need for assistance with ambulation, overestimating one's ability, and inability to correctly estimate the time. Risk was considered "low" if the patient had less than three affirmative answers and "high" if the patient had three or more.

Table 2

Results of the Univariate Analysis of Medications as Risk Factors for Falls

Medication	Cases n = 226 (%)	Controls n = 678 (%)	OR (95% CI)
Cardiovascular Agents	168 (74.3)	540 (79.6)	0.74 (0.52 – 1.05)
ACE inhibitors	46 (20.4)	143 (21.1)	0.96 (0.66 – 1.39)
Angiotensin II inhibitors	10 (4.4)	34 (5.0)	0.88 (0.43 – 1.8)
Antiadrenergic agents, centrally acting	17 (7.5)	28 (4.1)	**1.89 (1.01 – 3.52)**
Antiadrenergic agents, peripherally acting	13 (5.8)	30 (4.4)	1.32 (0.68 – 2.57)
Antianginal agents	32 (14.2)	92 (13.6)	1.05 (0.68 – 1.62)
Antiarrhythmics	45 (19.9)	200 (29.5)	**0.59 (0.41 – 0.86)**
Beta blockers	114 (50.4)	324 (47.8)	1.11 (0.82 – 1.50)
Calcium channel blockers	36 (15.9)	141 (20.8)	0.72 (0.48 – 1.08)
Diuretics	83 (36.7)	224 (33.0)	1.18 (0.86 – 1.61)
Loop diuretics	71 (31.4)	180 (26.5)	1.27 (0.91 – 1.76)
Potassium-sparing diuretics	7 (3.1)	42 (6.2)	0.48 (0.21 – 1.09)
Thiazide diuretics	19 (8.4)	42 (6.2)	1.39 (0.79 – 2.44)
Inotropic agents	19 (8.4)	70 (10.3)	0.80 (0.47 – 1.36)
Vasodilators	48 (21.2)	143 (21.1)	1.01 (0.70 – 1.46)
Vasopressors	34 (15.0)	164 (24.2)	**0.56 (0.37 – 0.83)**
Central Nervous System Agents	222 (98.2)	664 (97.9)	1.17 (0.38 – 3.59)
Analgesics	216 (95.6)	644 (95.0)	1.14 (0.55 – 2.35)
Narcotics	131 (58.0)	425 (62.7)	0.82 (0.60 – 1.12)
Narcotic combinations	81 (35.8)	304 (44.8)	**0.69 (0.50 – 0.94)**
NSAIDs	18 (8.0)	85 (12.5)	0.60 (0.35 – 1.03)
Salicylates	83 (36.7)	219 (32.3)	1.22 (0.89 – 1.67)
Anticonvulsants	126 (55.8)	270 (39.8)	**1.90 (1.41 – 2.58)**
Benzodiazepines	76 (33.6)	109 (16.1)	**2.65 (1.88 – 3.73)**
Hydantoins	17 (7.5)	11 (1.6)	**4.93 (2.27 – 10.70)**
Other[a]	51 (22.6)	129 (19.0)	1.24 (0.86 – 1.79)
Antiemetic/antivertigo agents	146 (64.6)	489 (72.1)	**0.71 (0.51 – 0.97)**
5HT3 receptor antagonists	95 (42.0)	368 (54.3)	**0.61 (0.45 – 0.83)**
Anticholinergics	47 (20.8)	198 (29.2)	**0.64 (0.44 – 0.91)**
Phenothiazines	45 (19.9)	139 (20.5)	0.96 (0.66 – 1.40)
Other[b]	34 (15.0)	98 (14.5)	1.05 (0.69 – 1.60)
Antiparkinson agents	56 (24.8)	207 (30.5)	0.75 (0.53 – 1.06)
Anticholinergics	48 (21.2)	193 (28.5)	**0.68 (0.47 – 0.97)**
Dopaminergics	9 (4.0)	18 (2.7)	1.52 (0.67 – 3.44)
Anxiolytics, sedatives, and hypnotics	145 (64.2)	433 (63.9)	1.01 (0.74 – 1.39)
Benzodiazepines	115 (50.9)	305 (45.0)	1.27 (0.94 – 1.71)
Other[c]	76 (33.6)	281 (41.4)	**0.72 (0.52 – 0.98)**
General anesthetics	39 (17.3)	190 (28.0)	**0.54 (0.37 – 0.79)**

Medication	Cases n = 226 (%)	Controls n = 678 (%)	OR (95% CI)
Muscle relaxants	28 (12.4)	168 (24.8)	**0.43 (0.28 – 0.66)**
Coagulation Modifiers	180 (79.6)	551 (81.3)	0.90 (0.92 – 1.32)
Anticoagulants	164 (72.6)	503 (74.2)	0.92 (0.66 – 1.29)
Antiplatelet agents	87 (38.5)	233 (34.4)	1.20 (0.88 – 1.63)
Thrombolytics	10 (4.4)	24 (3.5)	1.26 (0.59 – 2.68)
Gastrointestinal Agents	203 (89.8)	625 (92.2)	0.75 (0.45 – 1.25)
Antacids	71 (31.4)	271 (40.0)	**0.69 (0.50 – 0.95)**
Anticholinergics/antispasmodics	10 (4.4)	47 (6.9)	0.62 (0.31 – 1.25)
Antidiarrheals	10 (4.4)	13 (1.9)	**2.37 (1.02 – 5.48)**
GI stimulants	33 (14.6)	87 (12.8)	1.16 (0.75 – 1.79)
H2 antagonists	46 (20.4)	124 (18.3)	1.14 (0.78 – 1.67)
Laxatives	159 (70.4)	501 (73.9)	0.84 (0.60 – 1.17)
Proton pump inhibitors	105 (46.5)	363 (53.5)	0.75 (0.56 – 1.02)
Hormones	110 (48.7)	300 (44.2)	1.20 (0.88 – 1.62)
Adrenal cortical steroids	45 (19.9)	145 (21.4)	0.91 (0.63 – 1.33)
Sex hormones	8 (3.5)	20 (2.9)	1.21 (0.52 – 2.78)
Other[d]	40 (17.7)	92 (13.6)	1.37 (0.91 – 2.06)
Antidiabetic Agents	85 (37.6)	217 (32.0)	1.28 (0.94 – 1.75)
Insulin	82 (36.3)	203 (29.9)	1.33 (0.97 – 1.83)
Sulfonylureas	7 (3.1)	17 (2.5)	1.24 (0.51 – 3.04)
Psychotherapeutic Agents	111 (49.1)	265 (39.1)	**1.50 (1.11 – 2.04)**
Antidepressants	73 (32.3)	175 (25.8)	1.37 (0.98 – 1.90)
Phenylpiperazines	10 (4.4)	14 (2.1)	2.20 (0.96 – 5.02)
SSNRIs	13 (5.8)	32 (4.7)	1.23 (0.64 – 2.39)
SSRIs	40 (17.7)	103 (15.2)	1.20 (0.80 – 1.79)
Tetracyclics	7 (3.1)	17 (2.5)	1.24 (0.51 – 3.04)
Tricyclics	18 (8.0)	29 (4.3)	**1.94 (1.05 – 3.56)**
Antipsychotics	64 (28.3)	141 (20.8)	**1.51 (1.07 – 2.12)**
Haloperidol	14 (6.2)	14 (2.1)	**3.13 (1.47 – 6.68)**
Phenothiazines	37 (16.4)	104 (15.3)	1.08 (0.82 – 1.63)
Respiratory Agents	127 (56.2)	466 (68.7)	**0.58 (0.43 – 0.80)**
Antihistamines	59 (26.1)	240 (35.4)	**0.65 (0.46 – 0.90)**
Bronchodilators	66 (29.2)	199 (29.4)	0.99 (0.71 – 1.38)
Decongestants	23 (10.2)	122 (18.0)	**0.52 (0.32 – 0.83)**
Respiratory inhalants	13 (5.8)	43 (6.3)	0.90 (0.48 – 1.71)

Abbreviations: OR, odds ratio; CI, confidence interval

[a] Includes magnesium sulfate, gabapentin, levetiracetam, divalproex, pregabalin, topiramate, acetazolamide, lamotrigine, primidone, and valproic acid.

[b] Includes metoclopramide, lorazepam and dronabinol.

[c] Includes diphenhydramine, zolpidem, hydroxyzine, dexmedetomidine, ramelteon, buspirone, eszopiclone, doxepin and zaleplon.

[d]Includes glucagon, desmopressin, vasopressin, octreotide, calcitonin and raloxifene.

Table 3

Multivariate Model of Patient Characteristics and Medications Associated with Falls

	aOR (95% CI)
Patient Characteristics	
Gender (female)	0.69 (0.48 – 0.98)
History of falls	2.73 (1.79 – 4.16)
Ambulation	
No assistance needed	1 [Reference]
Bedrest	1.32 (0.72 – 2.42)
Assistive device	3.17 (1.47 – 6.80)
Person assistance	2.08 (1.31 – 3.31)
Body Mass Index	
Normal (18.5 – 24.9)	1 [Reference]
Underweight (≤18.5)	2.35 (1.17 – 4.74)
Overweight (25.0 – 29.9)	1.44 (0.92 – 2.25)
Obese (≥30)	1.58 (1.01 – 2.48)
Estimate of the time (confusion)	
Correct	1 [Reference]
Incorrect	2.44 (1.48 – 4.03)
Unable to answer	0.94 (0.49 – 1.78)
Dizziness	2.12 (1.05 – 4.28)
Incontinence	1.53 (1.00 – 2.33)
Medications	
Hydantoin anticonvulsants	3.25 (1.33 – 7.95)
Haloperidol	2.80 (1.16 – 6.77)
Tricyclic antidepressants	2.43 (1.21 – 4.90)
Benzodiazepine anticonvulsants	2.19 (1.46 – 3.29)
Insulin	1.46 (1.01 – 2.13)
Proton pump inhibitors	0.63 (0.44 – 0.90)
Muscle relaxants	0.44 (0.27 – 0.71)

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval Hosmer-Lemeshow goodness of fit test: chi-square =6.66; p=.57

Table 4

Comparison of the Number of High-Risk Medication Categories for Cases and Controls.

Number high-risk medications	Cases n = 226 (%)	Controls n=678 (%)	aOR[a] (95% CI)
0	81 (35.8)	380 (56.0)	1 [Reference]
1	93 (41.2)	234 (34.5)	1.55 (1.07 – 2.26)
2	43 (19.0)	60 (8.8)	3.39 (2.03 – 5.67)
3 – 4	9 (4.0)	4 (0.6)	11.82 (3.24 – 43.16)

Abbreviations: aOR, adusted odds ratio

[a]Odds ratios were adjusted for the following patient characteristics, which were significantly associated with falls in the multivarible model: gender, fall history, ambulation, BMI, ability to estimate the time, dizziness, and incontinence).