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An Exploration of the Association of Patient Characteristics and Pharmacological Treatments to Inpatient Falls among Patients At-risk for Falling during Hospitalization

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ABSTRACT

Introduction/Background: Falls may be the most commonly reported incidents in the acute care setting, and a frequent cause of harm in the hospital. Studies have focused on identifying risk factors for falls and interventions aimed at reducing the risk of falling. The purpose of this study was to describe and compare patient characteristics and pharmacological treatments between patients who fell and patients who did not fall, among a sample of patients deemed to be at-risk for falling during hospitalization. Additionally, the study aimed to identify independent predictors of falls among patients at-risk for falls during hospitalization.
Methods: An observational, cross-sectional study involving the analysis of retrospective patient records. A convenience sample of all patients with a Morse Fall Scale of ≥45 over a 1-year period, was extracted from electronic medical records. Descriptive statistics of demographic characteristics and medication classes were generated to compare those who fell to those who did not fall. To examine significant predictors of falls, logistic regression (univariate and multivariable) were employed.
Results/Findings: The sample consisted of 4,978 valid patient records. White non-Hispanics constituted 60% of the falls group but only 24% of the non-falls group. A larger proportion of those who fell received antiemetics or insulin compared to those who did not fall. Univariate regression analysis found that race and 39 medication classes were independently associated with falls. Multivariable regression analysis showed that race and 11 medication classes were associated with the odds of falling.
Conclusions: White patients were more likely to fall than patients of other races. New associations were found between the odds of falling and antiprotozoals, diagnostic agents, and gastrointestinal agents. Prospective studies are needed to determine the predictive accuracy of these factors. Bedside practitioners should understand the mechanism and onset of action of medications so that individualized safety precautions may be implemented. By including classes of medications as part of fall-risk assessment, patient safety may be optimized and falls avoided in this high risk population.

Keywords*: falls, inpatient, hospital, patient characteristics, medications, pharmacological treatment*

INTRODUCTION

Falls continue to present a major patient safety concern both in the community and in hospitals. In 2015, direct medical costs for fatal falls were estimated at $637.5 million and $31.3 billion for non-fatal injuries (Burns, et al., 2016). Falls is one of the most frequent causes of harm in the hospital. Bouldin et al., (2013) reported a prevalence rate of 3.56 per 1000 patient days and an injury rate of 0.93 per 1000 patient days. Thus, regulatory agencies, such as the Centers for Medicare and Medicaid Services (CMS) and The Joint

Commission (TJC), have placed great emphasis on fall prevention programs and have included this as a requirement for billing and accreditation (Quigley & White, 2013).

Definition of Falls

The National Database of Nursing Quality Indicators (NDNQI) in its 2016 guidelines, defined a patient fall as an unplanned descent to the floor with or without injury to the patient. NDNQI reports two fall indicators (rate of total falls per 1000 patient-days and the rate of falls with injury per 1000 patient-days), which were endorsed by the National Quality Forum.

Factors Associated with Falls

Studies focused on the prevention of falls have attempted to identify the factors that contribute to fall risk (Deandrea, et al., 2013; Dykes, Hurley, Benoit, & Middleton, 2009) as well as interventions (Dykes et al., 2010) that may help reduce the risk for falling in the acute care setting. Incorporating an externally validated instrument, such as Morse Fall scale, into the electronic medical record has been identified as an important strategy in identifying patients at-risk for falling (DuPree & Musheno, 2014). However, due to the multifactorial nature of falls, even externally validated tools have not been able to accurately assess the risk of falling on a consistent basis (Williams, Szekendi & Thomas, 2014).

Some studies have focused on identifying the modifiable and non-modifiable risk factors that may predict patient falls such as patient characteristics, fall risk assessment, unassisted ambulation, medications, bathroom-related/toileting, bed and chair alarms, call light, environment and equipment, handoff communication, education, and change management (DuPree & Musheno, 2014). Additionally, gait/balance deficit or lower extremity problems, confusion, use of sedatives/hypnotics, use of diabetes medications, increasing patient-to-nurse ratio and activity level of "up with assistance" compared with "bathroom privileges" were found to be associated with increased risk of falling (Krauss et al., 2005).

An exploratory research conducted by Tzeng and Yin (2008) found that only 13.5% of falls examined were medication-related falls. A more recent work found that pain medications/opiates, cardiac drugs/antihypertensives, sedatives/hypnotics, and anti-psychotics/ antidepressants were commonly taken by patients within the 24 hour period just prior to a fall (Williams, Szekendi & Thomas, 2014). These findings were similar to the study findings of Krauss and colleagues (2005) in which nonnarcotic analgesics, antiarrythmic agents, and sedatives/hypnotics were associated with falls, in addition to diabetes medications.

In summary, with the exception of the study by Krauss et al. (2005) and Anderson, Dolansky, Damato, and Jones (2014), most studies have been descriptive in nature and no attempt was made to determine what factors actually predicted the occurrence of falls among hospitalized patients (DuPree & Musheno, 2014; Tzeng & Yin, 2008; Williams, Szekendi, & Thomas, 2014). In Krauss et al. (2005), patients who fell were compared to patients who did not fall during hospitalization on a variety of potential predictors. The patients included in the study were assessed to be at varying levels of risk for falling on admission, therefore it is difficult to determine to what extent pre-existing risk may have confounded or contributed to the findings of the study. A more recent study conducted by Anderson et al. (2014) indicated that male gender and age greater than 65 were predictive of serious fall injury among hospitalized patients. Yet, there has been little research focusing on subgroups of patients at varying levels of risk for falling or the identification of factors associated with the occurrence of falls within such subgroups.

The present study focused on patients assessed to be at high risk for falling during hospitalization. The characteristics of those who actually fell were compared to those who did not fall and significant predictors were identified.

The study aims were to:

1. Describe the distribution of certain patient characteristics and pharmacological treatments among patients at-risk for falling during hospitalization.
2. Compare those who actually fell to those who were at-risk but did not fall during hospitalization for significant differences in patient characteristics and prescribed pharmacological treatments.
3. Determine the association of patient characteristics to the occurrence of falls among patients at-risk for falling during hospitalization.
4. Determine the association of pharmacological treatments to the occurrence of falls among patients at-risk for falling during hospitalization.
5. Identify independent predictors of falls among patients at-risk for falls during hospitalization.

METHODS

Institutional review board approval for the study was obtained in September of 2015. A waiver of informed consent was obtained since the study was of minimal risk and did not involve identifiable patient information, interventions or changes in patient care.

Design

A cross-sectional observational design was utilized to examine similarities and differences between patients who fell and patients who did not fall during their period of hospitalization. All medical records data included in the study were collected retrospectively.

Setting

The study was conducted at a 148-bed community hospital in southeastern United States. The patient population was racially and ethnically diverse; according to the U.S. Census Bureau (2010), the surrounding community is approximately 58% Hispanic, 31% Black, 10% White, and 1% other races. The hospital's unique location, surrounded by farmland but only 40 miles from a major metropolitan city allowed it to serve a mix of both rural and urban populations.

Sample

A convenience sample of 5,356 records from inpatients deemed to be at high-risk for falling at any point during hospitalization between July 1st, 2014 and June 30th, 2015 were included in the study. Patient-level data was extracted from electronic medical records, as well as administrative and clinical pharmacy databases. A pseudo identification number was assigned to each patient record. Medical record numbers were not retained in the study database. Patient records were included in the study if they had a documented Morse Fall Scale score of 45 or greater, indicating high-risk for falling at any point during hospitalization. Excluded from the study were outpatients and the records of patients with all recorded Morse Fall Scale scores of less than 45, no documented Morse Fall Scale score, and those with no Morse Fall Scale score documented prior to falling. After screening for inclusion and exclusion criteria, and the removal of 378 patient records with unrealistic or missing height and weight measurements, a total of 4,978 records were found eligible for the study.

Measures

Variables representing patient characteristics were selected based on the extant literature linking certain patient characteristics to the occurrence of falls during hospitalization and the researchers' determination of factor's within the hospital's unique patient population that may have contributed to falls. Patient characteristics measured on a continuous scale were age, height, and weight; categorical measures included patient gender, race, preferred language, insurance status, history of smoking, history of alcohol use, and primary admission diagnosis. In addition, the impact of patient comorbidities on the occurrence of falls during hospitalization was assessed using the Charlson Comorbidity Index (CCI). The CCI is a weighted index of 19 patient comorbidities, with demonstrated predictive validity for several hospital outcomes including complications, length of stay, mortality (Charlson, Szatrowski, Peterson & Gold, 1994; Johnson et al., 2015; Schmolders et al., 2015). By determining the presence or absence of the included comorbidities and adding their associated weights (which range between 1 and 6 points), a risk score is generated; higher scores indicate higher risk for mortality. Since its inception, the CCI has undergone several revisions, in this study scoring of the CCI was based on an updated version of weights and International Classification of Diseases 9th Edition (ICD-9) diagnostic codes representing patient comorbidities (Quan et al., 2005; Quan et al., 2011).

Variables representing pharmacological treatments were coded based upon major drug classification. Since the initial data was received in the form of generic drug names or brand names, members of the research team recoded each drug into their major drug classifications in accordance with the American Hospital Formulary Service (AHFS) – 2016 Drug Formulary and under the guidance and discretion of a research team member with pharmacological expertise. A total of 131 major drug classifications were represented within the sample.

Analysis

Analyses were conducted using RStudio 0.97.551 (R Studio, 2013) incorporating R 3.2.1 (R Core Team, 2015) open source statistical analysis software. Descriptive statistics using frequencies, percentages, and measures of central tendency were generated for the overall sample and subgroups of patients who fell and did not fall (study aims "1" & "2"). Univariate logistic regression analysis was conducted to identify factors associated with patient falls (study aims "3" & "4"); variables with a $p < .20$ were considered significant and were retained for multivariable modeling. Multivariable logistic regression using backward elimination was conducted to identify independent predictors of patient falls (study aim "5"); variables with a $p < .10$ were retained and used to build the final model.

RESULTS

Of the 4978 records included in the analysis, only 40 (0.80%) patients actually fell during their period of hospitalization while the remaining 4,938 did not fall. Table 1 provides a complete description of the sample demographics. Eight of the ten most frequently occurring medication classifications were similar for the overall sample, the subgroup that did not fall, and the subgroup that fell (Table 2). The administration of

those medications range from 40.8% to 83.2% of the sample. However, antiemetics and insulins were found to be among the ten most frequent medication classes for those who fell but not among those who did not fall.

Table 1

Subgroup Comparison based on Fall Status (Did Not Fall, Fell) and Description of the Overall Sample (N=4978)

	Did not Fall (*n* = 4938)		Fell (*n* = 40)		Overall sample (*n* = 4978)	
	n (%)	*M (sd)*	*n (%)*	*M (sd)*	*n (%)*	*M (sd)*
Age	--	61.8 (18.9)	--	59.5 (16.4)	--	61.8 (18.9)
Gender						
Male	2272 (46%)		19 (47.5%)		2291 (46%)	
Female	2666 (54%)		21 (52.5%)		2687 (54%)	
Race						
White Hispanic	2279 (46.15%)		7 (17.5%)		2286 (45.92%)	
White Non-Hispanic	1195 (24.20%)		24 (60%)		1219 (24.49%)	
Black/African American	1112 (22.52%)		8 (20%)		1120 (22.50%)	
Black Hispanic	188 (3.81%)		1 (2.5%)		189 (3.80%)	
Other	131 (2.65%)		0 (0%)		131 (2.63%)	
Asian/Pacific Islander	33 (0.67%)		0 (0%)		33 (0.66%)	
Preferred Language						
English	3918 (79.34%)		37 (92.5%)		3955 (79.45%)	
Spanish	966 (19.56%)		2 (5.00%)		968 (19.45%)	
Creole	33 (0.67%)		1 (2.50%)		34 (0.68%)	
Other	21 (0.43%)		0 (0.00%)		21 (1.42%)	
Insurance Status						
Insured	4651 (94%)		38 (95%)		4689 (94%)	
Self Pay	287 (6%)		2 (5%)		289 (6%)	
Smoker						
Yes	1768 (35.8%)		19 (47.5%)		1787 (35.9%)	
No	3170 (64.2%)		21 (52.5%)		3191 (64.1%)	
Alcohol Use						
Yes	1094 (22.2%)		9 (22.5%)		1103(22.2%)	
No	3844 (77.8%)		31 (77.5%)		3875 (77.8%)	
CCI[a]						
0	2405 (48.7%)		18 (45%)		2423 (48.7%)	
1	770 (15.6%)		9 (22.5%)		779 (15.6%)	
2	635 (12.8%)		3 (7.5%)		638 (12.8%)	
3	348 (7%)		3 (7.5%)		351 (7.1%)	
4	319 (6.6%)		5 (12.5%)		324 (6.5%)	
5	129 (2.6%)		0 (0%)		129 (2.6%)	
6	164 (3.3%)		1 (2.5%)		165 (3.3%)	
7	77 (1.6%)		0 (0%)		77 (1.5%)	
8	47 (0.9%)		1 (2.5%)		48 (1%)	
9	23 (0.5%)		0 (0%)		23 (0.5%)	
10	15 (0.3%)		0 (0%)		15 (0.3%)	
11	3 (0.05%)		0 (0%)		3 (0.05%)	
12	1 (0.02%)		0 (0%)		1 (0.02%)	
13	2 (0.03%)		0 (0%)		2 (0.03%)	

Note. [a]CCI = Charlson Comorbidity Index score.

Table 2

Description of Top Ten Medication Classifications by Subgroup and for the Overall Sample (N = 4978)

Did not Fall (*n = 4938*)		Fell (*n = 40*)		Overall Sample (*n = 4978*)	
Medication Classification	*n (%)*	Medication Classification	*n (%)*	Medication Classification	*n (%)*
Replacement Preparations	4143 (83.9%)	Replacement Preparations	37 (92.5%)	Replacement Preparations	4143 (83.2%)
Anticoagulants	3724 (75.4%)	Anticoagulants	31 (77.5%)	Anticoagulants	3724 (74.8%)
Proton-pump Inhibitors	3350 (67.8%)	Proton-pump Inhibitors	30 (75.0%)	Proton-pump Inhibitors	3350 (67.3%)
Antibacterials	3144 (63.7%)	Antibacterials	30 (75.0%)	Antibacterials	3144 (63.2%)
Opiate Agonists	2889 (58.5%)	Opiate Agonists	29 (72.5%)	Opiate Agonists	2889 (58.0%)
NSAIDS[a]	2145 (43.4%)	Anticonvulsants	26 (65.0%)	NSAIDS[a]	2145 (43.1%)
Benzodiazepines	2141 (43.4%)	Benzodiazepines	26 (65.0%)	Benzodiazapines	2141 (43.0%)
Beta-Adrenergic Blockers	2103 (42.6%)	Antiemetics	24 (60.0%)	Beta-Adrenergic Blockers	2103 (42.3%)
Anticonvulsants	2082 (42.2%)	Analgesics/Antipyretics	21 (52.5%)	Anticonvulsants	2082 (41.8%)
Analgesics/Antipyretics	2033 (41.2%)	Insulins	19 (47.5%)	Analgesics/Antipyretics	2033 (40.8%)

Note. [a]NSAIDS = Non-steroidal anti-inflammatory drugs.

Results of Univariate Regression

A total of 142 predictor variables were available to be regressed against fall status, including 131 variables representing a variety of major medication classifications. Univariate logistic regression found 40 significant ($p < .20$) predictors of patient falls. From these results, only race was retained among the demographic variables, the remaining 39 were representative of major medication classifications. These results are presented in Table 3.

Results of Multivariable Regression Analysis

Prior to multivariable regression, racial categories were collapsed into three groups ("White Hispanic", "Black/African American", "White-Non Hispanic and Other"). We created the "White Non-Hispanic and Others" category from the "White", "Asian/Pacific Islander", "Black Hispanic" and "Other" race categories since there was no significant difference among these categories at the 5% significance level based on results from the univariate regression. The "White Non-Hispanic and Others" category was then used as reference category for race in the multivariable model. The multivariable model was then constructed which included race and the 39 medication classes from the univariate model. The results of the multivariable analysis are presented in Table 4.

Considering the limited number of fall events and a high number of redundant medication classes found in the results (Table 4), we desired to reduce this model further. We built a new multivariable logistic regression model and excluded medication classes that did not have a p-value < .10 from the previous model. The final model is presented in Table 5. The Likelihood Ratio Test (LRT) indicated that the overall model was significant [$\chi^2(13) = 78.31$, $p = .000$]. Each of the 12 variables included in the model were significant predictors of fall status. The odds of falling for the Black/African American group was almost 3 times lower, and the White Hispanic group was more than 6 times lower compared to patients of White-Non Hispanic and Other races. Most of the medication classes than 13 times lower odds of falling. Patients who were administered gastrointestinal drugs-miscellaneous classification had odds of falling that were more than 49 times higher, barbiturates more than 10 times higher, diagnostic agents 6 times higher, centrally acting skeletal muscle relaxants by almost 5 times higher than those who were not. In addition, patients who were administered antiparkinsonian agents had an odds of falling about 4.5 times higher, general anesthetics by about 4 times higher, thiazide diuretics by more than 3 times higher, local anesthetics by almost 3 times higher, autonomic drugs-miscellaneous by about 2.6 times higher, and antiemetics 2.4 times higher than those who were not.

DISCUSSION

In this study, the investigators observed that White Hispanics and Black/African Americans had lower odds of falling compared to other races. While White Hispanics and Black/African Americans together constituted about 68% of the sample, White Non-Hispanics were only 24% of the sample but constituted 60% of the group that experienced falls. Most of the previous studies looked at the association of other patient characteristics such as age and gender (Deandrea et al., 2016; Williams, Szekendi, & Thomas, 2014) to the occurrence of falls. There was a dearth of information in the literature regarding the relationship of race to the occurrence of falls except for an earlier study conducted in the community that identified White race as a risk factor for a serious fall-related injury (Tinetti, Doucette, Claus, & Marottoli, 1995). This earlier finding was similar to what we found in our study of which the group containing White Non-Hispanics had higher odds of falling. We were not

Table 3

Results of Univariate Analysis - Logistic Regression results of Fall Status vs. each Predictor (N = 4978)

Predictor	*β*	*SE(β)*	*Z*	*p*
Race[a]				
Asian/Pacific Islander	-15.658	1872.033	-0.008	.993
Black Hispanic	-1.329	1.024	-1.298	.194
Black/African American	-1.027	0.410	-2.502	.012
Other	-15.653	939.583	-0.017	.987
White Hispanic	-1.878	0.431	-4.356	.000
Medication Class[b]				
Alpha and Beta Adrenergic Agonists	0.952	0.532	1.790	.073
Ammonia Detoxicants	0.888	0.381	2.330	.020
Analgesics and Antipyretics	0.475	0.318	1.490	.140
Angiotensin II Receptor Antagonists	0.545	0.398	1.370	.170
Antibacterials	0.564	0.366	1.540	.120
Anticonvulsants	0.957	0.333	2.880	.004
Antidepressants	0.833	0.333	2.500	.013
Antiemetics	0.879	0.324	2.710	.007
Antimuscarinics Antispasmodics	0.727	0.446	1.630	.100
Antiparkinsonian Agents	1.509	0.610	2.470	.013
Antiprotozoals	-1.766	1.014	-1.740	.081
Antitussives	0.747	0.482	1.550	.120
Antivirals	0.907	0.532	1.710	.088
Anxiolytics Sedatives and Hypnotics	0.877	0.398	2.200	.028
Autonomic Drugs Miscellaneous	1.092	0.420	2.600	.009
Barbiturates	1.658	1.033	1.600	.110
Benzodiazepines	0.904	0.333	2.720	.007
Blood Derivatives	0.693	0.531	1.300	.190
Caloric Agents	0.662	0.446	1.480	.140
Carbonic Anhydrase Inhibitors	1.836	0.614	2.990	.003
Cathartics and Laxatives	0.511	0.321	1.590	.110
Central Alpha Agonists	0.585	0.446	1.310	.190
Centrally Acting Skeletal Muscle Relaxants	1.539	0.535	2.870	.004
Diagnostic Agents	1.642	0.536	3.060	.002
General Anesthetics	1.380	0.448	3.080	.002
GI Drugs Miscellaneous	4.148	1.235	3.360	.001
Glycogenolytic Agents	1.503	1.030	1.460	.140
Immunosuppressive Agents	1.658	1.033	1.600	.110
Insulins	0.457	0.318	1.440	.150
Local Anesthetics	1.220	0.420	2.900	.004
Neuromuscular Blocking Agents	1.540	1.031	1.490	.140
Opiate Agonists	0.650	0.355	1.830	.067
Prokinetic Agents	0.847	0.482	1.757	.079
Replacement Preparations	0.916	0.602	1.523	.128
Serums	3.048	1.092	2.791	.005
Somatostatin Agonists	0.931	0.606	1.536	.125
Thiazide Diuretics	1.060	0.532	1.991	.046
Vaccines	0.548	0.367	1.492	.136
Vitamins	0.938	0.325	2.889	.004

Note. Criteria for statistical significance: $p < .20$: [a]Comparison group is White Non-Hispanic. [b]Comparison group is absent (omitted from the table). The coding for the medication classes was dichotomous: 1 = present, 0 = absent.

Table 4

Multivariable Logistic Regression Results – Predictors of Fall Status

Predictor	*β*	*SE(β)*	*Z*	*p*
Constant	-5.848	0.694	-8.429	.000
Race[a]				
Black/African American	-0.818	0.435	-1.883	.060*
White Hispanic	-1.849	0.474	-3.897	.000*
Medication Class[b]				
Alpha and Beta Adrenergic Agonists	-0.546	0.788	-0.692	.489
Ammonia Detoxicants	-0.035	0.477	-0.073	.942
Analgesics and Antipyretics	-0.043	0.370	-0.117	.907
Angiotensin II Receptor Antagonists	0.360	0.448	0.802	.422
Antibacterials	0.082	0.420	0.195	.845
Anticonvulsants	0.337	0.380	0.887	.375
Antidepressants	0.483	0.369	1.308	.191
Antiemetics	0.743	0.384	1.934	.053*
Antimuscarinics Antispasmodics	-0.272	0.541	-0.502	.616
Antiparkinsonian Agents	1.532	0.691	2.217	.027*
Antiprotozoals	-2.882	1.106	-2.606	.009*
Antitussives	0.454	0.544	0.834	.404
Antivirals	0.484	0.606	0.799	.424
Anxiolytics Sedatives and Hypnotics	0.529	0.445	1.187	.235
Autonomic Drugs Miscellaneous	0.867	0.467	1.857	.063*
Barbiturates	2.152	1.150	1.872	.061*
Benzodiazepines	0.157	0.382	0.411	.681
Blood Derivatives	0.004	0.659	0.006	.995
Caloric Agents	0.039	0.593	0.065	.948
Carbonic Anhydrase Inhibitors	1.080	0.758	1.424	.154
Cathartics and Laxatives	-0.305	0.389	-0.784	.433
Central Alpha Agonists	0.115	0.484	0.238	.812
Centrally Acting Skeletal Muscle Relaxants	1.370	0.595	2.300	.021*
Diagnostic Agents	2.021	0.674	2.999	.003*
General Anesthetics	1.295	0.669	1.936	.053*
GI Drugs Miscellaneous	4.034	1.563	2.582	.010*
Glycogenolytic Agents	0.704	1.220	0.577	.564
Immunosuppressive Agents	1.360	1.176	1.156	.248
Insulins	0.101	0.390	0.259	.795
Local Anesthetics	0.841	0.477	1.764	.078*
Neuromuscular Blocking Agents	0.157	1.314	0.120	.905
Opiate Agonists	-0.083	0.419	-0.197	.844
Prokinetic Agents	0.411	0.552	0.745	.456
Replacement Preparations	0.178	0.636	0.280	.780
Serums	2.140	1.316	1.626	.104
Somatostatin Agonists	0.188	0.712	0.263	.792
Thiazide Diuretics	1.122	0.608	1.847	.065*
Vaccines	0.207	0.404	0.513	.608
Vitamins	0.374	0.377	0.991	.322

Note. *Significant at $p < .10$. [a]Comparison group is "White Non-Hispanic and Others". [b]Comparison group is absent (omitted from the table). The coding for the medication classes was dichotomous: 1 = present, 0 = absent

Table 5

Multivariable Logistic Regression Results

Predictor	β	SE(β)	Z	*p*	OR	[95% CI]
Constant	-5.052	1.376	-15.840	0.000	0.006	[0.003 – 0.011]
Race[a]						
Black/African American	-0.816	1.518	-1.953	0.051*	0.442	[0.183 – 0.962]
White Hispanic	-1.820	1.580	-3.977	0.000	0.162	[0.061 – 0.374]
Medication Classification[b]						
Antiemetics	0.856	1.408	2.499	0.012	2.353	[1.209 – 4.675]
Antiparkinsonian Agents	1.512	1.916	2.325	0.020	4.536	[1.017 – 14.115]
Antiprotozoals	-2.604	2.844	-2.492	0.013	0.074	[0.004 – 0.372]
Autonomic Drugs Miscellaneous	0.949	1.553	2.154	0.031	2.583	[1.006 – 0.795]
Barbiturates	2.349	3.006	2.134	0.033	10.474	[0.54 – 62.241]
Centrally Acting Skeletal Muscle Relaxants	1.531	1.745	2.750	0.006	4.621	[1.323 – 12.398]
Diagnostic Agents	1.806	1.869	2.887	0.004	6.086	[1.521 – 18.744]
General Anesthetics	1.432	1.601	3.043	0.002	4.187	[1.513 – 9.873]
GI Drugs Miscellaneous	3.896	4.814	2.479	0.013	49.185	[1.401 – 983.747]
Local Anesthetics	1.013	1.550	2.311	0.021	2.753	[1.077 – 6.15]
Thiazide Diuretics	1.205	1.800	2.050	0.040	3.337	[0.878 – 9.357]

Note. Criteria for statistical significance: $p < .05$. *Significant at $p < .05$ as one of the levels of the Race variable. [a]Comparison group is "White Non-Hispanic and Others". [b]Comparison group is absent (omitted from the table). The coding for the medication classes was dichotomous: 1 = present, 0 = absent.

surprised by some of the results regarding the impact of pharmaceutical agents. A substantial number of drugs have been previously identified in the Beers (American Geriatrics Society, 2015) list to have an association with the incidence of falls. We noted that a larger proportion of those who fell received antiemetics or insulin compared to those who did not fall. These medications are listed in the Beers criteria for potentially inappropriate medication use in older adults (American Geriatrics Society, 2015). In our study, patients who took antiemetics had 2.4 times higher odds of falling.

Thiazide diuretics were observed to be associated with increased odds of falling. Thiazides have been associated with falls particularly among women older than 70 years of age. It is suspected that a common side effect of these drugs, hyponatremia, is responsible (Hwang & Kim, 2010). Patients with symptomatic thiazide-induced hyponatremia tend to experience muscle weakness, fatigue, and loss of energy which may contribute to falls (Liamis, Filippatos, & Elisaf, 2016; Sardar & Eilbert, 2015). While hyponatremia tends to occur most frequently on initiation of therapy, it may occur at any time during treatment as a consequence of physiological or environmental changes (Liamis et al., 2016).

The study results also indicated that barbiturates were associated with increased odds of falling. Barbiturates have strong sedative-hypnotic effects even at low doses, therefore, causing the following side effects: drowsiness, lethargy, dizziness (American Geriatrics Society, 2012). This finding was consistent with that of Dauphinot et al. (2014) who indicated that increased exposure to anticholinergic and sedative medications during hospital stay is associated with increased risk of inpatient falls. Similarly, Krauss et al. (2005) found that the use of sedative-hypnotics was a predictor that significantly increased a patient's risk of falling in the hospital. The study finding that administration of central skeletal muscle relaxants (SMR) was associated with falls was not surprising. These drugs are anticholinergic agents and have documented side effects such as confusion and sedation, which may lead to falls.

Antiparkinsonian drugs also increased the odds of falling. Many of the antiparkinsonian agents such as Carbidopa-Levodopa may cause dizziness and confusion which may contribute to the occurrence of falls. However, the symptoms of Parkinson's disease itself including muscular stiffness, freezing, shuffling gait, balance impairment or stooped posture make it difficult to discern to what extent the antiparkinsonian drugs may have contributed to the observed incidence of falls (Chen & Swope, 2014). It has been noted in the literature, that gait/balance impairment or lower extremity problem was another predictor that significantly increased a patient's risk for falling (Krauss et al., 2005).

Our study revealed that local and general anesthetic agents were associated with increased odds of falling for patients. Interestingly, the study of Anderson et al. (2014) showed that surgical patients were statistically more likely than medical patients to sustain a serious fall injury when the category "no

injury" was removed from the analysis. Although the research regarding postoperative falls is limited and overall incidence is low at 1.6 cases per 10,000 patients (Lam et al., 2016), we may expect falls in this population because the residual pharmacologic and neuromuscular blocking effects of anesthetic agents may predispose patients to falls. Patients who receive anesthesia, especially surgical patients, receive a combination of agents that have synergistic effects on the central nervous system (CNS), neuromuscular and GI system that can last for several hours or even days. It is worth mentioning that Lam et al. (2016) observed that post-anesthesia falls occurred at the bedside usually during the day with the presence of clinicians and after the first uneventful getting out of bed. Although local anesthetic agents such as lidocaine patch are not fully systemically absorbed, CNS side effects such as fainting, dizziness, weakness, confusion, and blurred vision are still reported (Drasner, 2015).

Our study revealed a previously unreported link between administration of diagnostic agents and an increased odds of falling. We did not find any prior studies associating these drug category to patient falls. However, some of the diagnostic agents such as diatrizoate meglumine and diatrizoate sodium, have high osmolality and are water-soluble (Salix Pharmaceuticals, 2016). This may lead to electrolyte imbalances, diarrhea and dehydration resulting in hypovolemia and hypotension. This is interesting to note because based on this hospital's previous analysis of post-fall data, the most common reason why patients fell was toileting. This was consistent with a large scale study conducted by Williams et al. (2014) who noted that toileting constituted 23% of common patient activities at the time of a fall. Special care should be taken to adequately hydrate patients before the administration of some diagnostic agents to prevent dehydration and to offer toileting frequently after the procedure.

Another new finding was the association of methylnaltrexone with the incidence of falls. Methynaltrexone is a Mu opioid antagonist that is indicated for the treatment of opioid-induced constipation (Salix Pharmaceuticals, 2016). It works by reducing the constipating effects of opioids without impacting the analgesic effects of opioids (Salix Pharmaceuticals, 2016). Because methylnaltrexone does not cross the blood-brain barrier, we did not expect it to have any impact on falls (Salix Pharmaceuticals, 2016). However, we have surmised that this is more likely to be the result of its rapid onset of action rather than its mechanism of action. Studies have suggested that 30% of patients on methylnaltrexone have a bowel movement within 30 minutes of the first dose (Slatkin et al., 2009; Thomas et al., 2008). One of its known side effects is diarrhea. It is possible that falls may occur among some patients who suddenly feel the need for toileting and in the emergent rush to the bathroom for relief fail to call for assistance from staff.

An interesting finding in this study was that antiprotozoal agents were associated with decreased odds for falling for the patients. The vast majority of the medications administered in this category was metronidazole given intravenously or orally. This medication is frequently administered to patients with protozoal and bacterial infections. It is also usually given for certain gastrointestinal infections such as amoebeasis, intra-abdominal infection, Clostridium difficile-related diarrhea, Chron's disease and Helicobacter pylori (American Society of Hospital Pharmacists, 2016). This was the only drug category that lowered the patient's odds of falling. Perhaps, since these medications were given to patients with gastrointestinal symptoms, certain precautions have already been implemented and more vigilance was offered by the staff to anticipate and meet toileting needs.

Strengths

This is the first study that we know of to examine fall-related outcomes among patients deemed at high-risk for falling in the hospital setting. It was performed using a large sample of 4,978 unique medical records. Unlike previous studies, we did not include environmental factors (e.g. raised bedrails, non-slip footwear, and floor type) because of the ubiquity in the implementation of such safety measures within hospitals. By focusing on non-modifiable patient characteristics and pharmaceutical treatments, we identified a parsimonious list of 12 factors associated with falls among high-risk patients. Thus, we expect these findings will be amenable for follow-up validation studies and eventual translation to the practice setting.

Limitations

This study was conducted at a single hospital, therefore the findings may not be readily generalized to other populations. As with all observational research, our results should not be interpreted to indicate causation but rather, association. Further, the accuracy of the results of studies based on medical records data are contingent upon the accuracy and completeness of the medical record and its abstraction. In addition, during the year covered by our study the facility had a low incidence of falls and a large number of patients deemed at high-risk for falling, this resulted in an unbalanced sample. We excluded the records of patients who did not receive a Morse Fall Scale score prior to falling, we cannot say for certain that such

patients were not different in some way from those who were scored.

Implications

Certain medications are known risk factors for falls, which the literature and the results of this study support. Nevertheless, there were certain medication classes identified in this research as predictors for falls that were not previously identified in the literature. It is important to assure that the bedside clinician knows the mechanism and onset of action of these medications and implement safety precautions towards falls prevention. For example, certain gastrointestinal medications have a rapid onset of action which necessitates that toilet facilities should be nearby immediately following administration. Additionally, assistance with toileting should also be immediately available to patients so as to minimize risk for falls on their way to the bathroom. It would further enhance patient safety, if patients taking general and even local anesthetic medications are flagged so that fall risk reassessment can be conducted more frequently. This is particularly important in light of recommendations that post-surgical patients are to be encouraged to get out-of-bed as early as possible in avoidance of post-operative pneumonia and other complications. The surveillance for fall risk and assistance with ambulation should still be offered after the first successful ambulation when patients could still be experiencing the residual effects of the anesthetic agents.

The results of this study indicate the need for future research regarding predictors for falls among high-risk patients. Replication studies with more balanced sample sizes may shed light on the consistency of our findings. Further, there is an opportunity to identify subpopulations of patients who are at highest risk by examining how necessary treatments may interact and contribute to the occurrence of falls during hospitalization.

CONCLUSION

Some hospitalized patients fall despite the best efforts of individual clinicians and organizations to mitigate risk within the care environment. Thus, preventing falls will continue to be a patient safety imperative in the acute care setting. Due to the multifactorial causation of falls, hospitals may need to implement several approaches in order to adequately address the problem. Knowledge regarding non-modifiable patient characteristics and necessary pharmacological treatments that predispose patients for falling are an invaluable addition to our understanding of factors contributing to patient fall-risk as well as the improved alignment of safety precautions based on individual patient's needs.

DECLARATION OF INTEREST

The authors whose names are listed below have indicated that they have no affiliations with or involvement in any organization or entity with any financial interest in the subject matter or materials discussed in this manuscript.

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