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Fall injuries, associated deaths, and 30-day readmission for subsequent falls are increasing in the elderly US population: a query of the WHO mortality database and National Readmission Database from 2010 to 2014

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Purpose: Clinicians anecdotally noted that elderly patients who suffered from traumatic injuries (falls or other injuries) often re-present and are readmitted with fall injuries. Herein, we hypothesized that fall injuries and fall-related deaths and readmissions are increasing over time, and assessed whether the overall rates of death, hospital admission, and 30-day readmission due to falls increased from 2010 to 2014 in the elderly population (≥65) in the US.

Patients and methods: The WHO mortality database and the National Readmission Database (NRD) were queried to assess rates of deaths and hospital admissions and 30-day readmissions associated with fall injuries in the elderly population that presented with trauma. Descriptive statistics were obtained. The generalized linear mixed modeling (GLMM) framework was utilized to examine the relationship between fixed-effect predictor variables and the dichotomous outcome, indicating readmission within 30 days of previous discharge while accounting for hospital clustering with a random intercept.

Results: Fall-related death increased by 1.4% from 2010 to 2014. Similarly, the hospital admission rate increased by 2% and was mainly associated with increased admission of elderly 65–74 years old. Approximately 55% of the fall patients were placed in nursing facilities in 2010, and this rate increased by 3% from 2010 to 2014. Thirty-day readmission rates for fall and trauma patients remained stable from 2010 to 2014. However, the rate of fall patients readmitted within 30 days for a subsequent fall increased from 15.6% to 17.4% between 2010 and 2014.

Conclusion: Our data indicate a steady increase in deaths and admissions for fall injuries in the elderly population. Strikingly, the incidence of readmission for a subsequent fall is increasing. With the aging population, this trend is likely to continue and highlights the need for elderly social support systems and fall prevention programs.

Keywords: elderly, falls, National Readmission Database, WHO mortality database

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Introduction

In the US, the number of elderly is now larger than it has ever been in history. The 2010 census reveals that there are 40.3 million people aged 65 years or older. This is a 5.3% increase compared to the 2000 census.[1,2] According to the census bureau projections, the elderly population (65 and older) is expected to more than double between 2012 and 2060. The elderly would represent just over 20% of the population

by the end of the period. Moreover, the 85 and older population is expected to more than triple, reaching 4.3% of the total population by 2060.[2] By 2030, all baby boomers in the US will be older than 65 years, which will expand the size of the older population such that one in every five residents will be of retirement age. For the first time in US history, the number of older adults will outnumber children at this time.[3] The number of elderly patients experiencing traumatic injuries increases as the elderly population grows. In fact, the elderly are the fastest-growing trauma patient population, making up 25% of patients admitted for traumatic injuries in 2011.[4] Among the mechanisms of traumatic injury, falls are the leading cause of non-fatal injuries in patients 65 years of age and older (63.8% of injuries in 2015).

Each year, 2.8 million elderly patients are treated in emergency departments for fall injuries, which accounts for 10–15% of all emergency department visits.[5–7] Falls are the leading cause of injury-related death in the elderly as well.[8] Fall injury leads to 800,000 hospitalizations a year, the majority of which are due to head injury or hip fracture.[5,6] Not only are these injuries serious, but also they are costly. In 2015, the total medical costs for falls was more than $50 billion.[9,10] Although this is a large number, it underestimates the true incidence and cost of falls in the elderly. It is suggested that somewhere between 25% and 30% of the elderly fall, but less than half tell their doctor.[11] These untreated falls become important because, once a person experiences a fall, her/his risk of falling again doubles.[12]

The initial traumatic injury or fall sustained by a patient is important, but the long-term effects of these injuries stretch far beyond their index hospitalization. Multiple studies looked at readmissions following traumatic injury in both the general population as well as in the elderly.[4,13,14] One such study found a readmission rate of 20.6% overall and 26.9% for falls.[14] Focusing only on elderly trauma patients, using statewide data for Washington State, Fawcett et al showed that patients who were 55 years of age and older who survived their initial hospitalization had a readmission rate of 7.9% at 30 days and 25.2% at 1 year.[13] Additionally, they showed that the strongest risk factors for readmission were an initial trauma that resulted in severe head injury and discharge to a skilled nursing facility (SNF). A study examining the long-term outcomes for elderly patients who sustained a ground-level fall indicated that, within 1 year of injury, 44.6% of the patients were readmitted.[4] Furthermore, they showed that over half (51%) of the patients who were admitted with a ground-level fall were discharged to a SNF, and discharge to a SNF led to a three-fold greater risk of 1-year

mortality – 48% of patients who discharged to a SNF dying by the end of the follow-up period. Although there have been many single-center or statewide studies, there have not been any large national studies looking at the outcomes following discharge for elderly patients who sustain traumatic injuries – specifically, the rate of readmission following traumatic injury in the elderly population. In particular, how often and why patients who are admitted for a trauma are readmitted (either for another trauma, specifically a fall, or for some other reason) have not been assessed.

Until recently, evaluation of readmissions following traumatic injury at the national level was difficult. The National Readmission Database (NRD) is a new Healthcare Cost and Utilization Project that allows us to examine nationally estimated rates for readmission of elderly patients following admissions for traumatic injuries. This annually produced dataset tracks readmissions across all acute-care hospitals within its participating states.

The purpose of this study was to examine the factors that lead elderly patients who sustain traumatic injuries to be readmitted to the hospital. We hypothesized that fall injuries, their resultant deaths, and readmissions related to their falls are increasing over time and that certain patient populations, based on age or comorbidity profile, would be at greater risk of readmission, thereby allowing us to create interventions to prevent readmission targeted at these groups. This study is the first to provide estimates of elderly trauma all-cause unscheduled 30-day readmission rates by patient demographics and injury characteristics describing readmission diagnoses and risk factors. To more fully understand the effects of fall injuries in the elderly, we also examined the WHO mortality database to determine the mortality rate for falls in the US.

Materials and methods
Ethical statement
This study was deemed exempt by the University of Iowa Institutional Review Board (# 201709803) as it does not meet the regulatory definition of human subject research and does not require review by the institutional review board, because, at the University of Iowa, this activity is limited to analysis of de-identified data from a national database.

Data sources
WHO mortality database
We queried the WHO mortality database to assess the number of deaths related to fall injuries for people 65 years of age and older from 2010 to 2014.[15] The WHO database compiles data

on mortality and cause of death by age and sex for 144 member states from 1950 to the present. These data are reported by the civil registration systems of member countries. Cause-of-death data are included in the database only for countries that reported medically certified causes of death using the International Classification of Diseases (ICD) codes. The cause-of-death statistics are from country civil registration systems. When a death occurs, this event is registered at the local civil registry with information on the cause of death. The information is then compiled by the national authority and submitted to WHO every year; the WHO only publishes the medically certified deaths. Data obtained by the WHO mortality database were validated by comparing the total number of male and female elderly (≥65 years) who died from a fall to the data available through the Centers for Disease Control and Prevention (CDC) Web-based Injury Statistics Query and Reporting System (WISQARS™). This database contains fatal injury information from death certificates filed in state vital-statistics offices and includes causes of death reported by attending physicians, medical examiners, and coroners. The WHO data were the same as those obtained using the WISQARS database (data not shown).

Data were collected from 2010 to 2014 to avoid any potential consistency issues associated with the change from ICD 9 to ICD 10 codes which took place in 2015.

National Readmission Database

We queried the NRD – part of a family of databases and software tools developed for the Healthcare Cost and Utilization Project (HCUP). The Agency for Healthcare Research and Quality (AHRQ) launched the NRD in 2015. The NRD is a unique and powerful database designed to support various types of analyses of national readmission rates for all payers and the uninsured. The NRD are calendar year files based on discharge date for all data years except 2015. The NRD contains clinical and nonclinical variables that support readmission analyses, with safeguards to protect the privacy of individual patients, physicians, and hospitals. There is no data element identifying whether sequential inpatient stays are related or unrelated. The NRD is drawn from the HCUP State Inpatient Databases (SID), which are part of the family of databases and software tools developed for the HCUP. The SID includes inpatient discharge records from community hospitals in that state, including discharge from observation admissions. The SID files encompass all patients, regardless of payer, providing a unique view of inpatient care in a defined market or state over time. Forty-nine states participate in the SID, which encompasses approximately 97% of all US

community hospital discharges. The NRD was constructed from 27 States, accounting for 57.8% of the total US resident population and 56.6% of all US hospitalizations. It uses reliable, verified patient linkage numbers in the SID that could be used to track the patient across hospitals within a state, while adhering to strict privacy guidelines. Unweighted, the NRD contains data from approximately 17 million discharges each year. Weighted, it estimates roughly 36 million discharges.

The NRD is composed of more than 100 clinical and nonclinical variables for each hospital stay (https://www.hcup-us.ahrq.gov/nrdoverview.jsp#about). To avoid consistency issues associated with the change from ICD 9 to ICD 10 codes, NRD data files from 2010 to 2014 were purchased from the HCUP. Hospitalizations of elderly patients (≥65 years) with a trauma principal diagnosis were our index events. Trauma patients were defined as those whose first five diagnosis codes (dx1–dx5) were ICD-9 injury diagnoses codes for injury and poisoning (800–999) or any E-code belonging to the external cause of injury category: E800–E849 or E880–E928, excluding patients with codes for superficial injury, foreign bodies, or late effects of injury. E-codes were used to better characterize the type of fall incurred by the elderly: E-code E885.0 to E886.9 code for same-level falls; E880.0 to E880.9 code for fall from stairs or steps; E881.0 to E884.9 code for fall from height; and E888.0 to E888.9 code for other or unspecified falls. Exclusion criteria included patients injured in December due to our inability to determine 30-day readmission secondary to the design of the database.

Statistical analysis

Descriptive statistics were used to present the WHO mortality data for years 2010–2014. The number of elderly who died because of a fall injury was corrected to the total number of deaths due to a fall injury (regardless of age) for each year and presented as a percentage.

Statistical analysis of the NRD data was conducted using SAS version 9.4 (SAS Institute, Cary, NC, USA). We employed the generalized linear mixed modeling (GLMM) framework for our analyses, which allowed us to examine the relationship between fixed-effect predictor variables and the dichotomous outcome indicating admission and readmission within 30 days of a previous discharge, while accounting for hospital clustering with a random intercept. These predictors can be divided into patient- and hospital-related data. Patient-related variables include age group, gender, length of stay, discharge to an SNF vs other, having an ED visit, and insurance information. In addition to patient characteristics, we were interested in the relationship between 29 different

comorbidities and the total number of chronic comorbidities each patient had at discharge. The goodness-of-fit of each model was compared using the Bayesian information criterion (BIC).[16] This measure is an extension of the Akaike information criterion (AIC)[17,18] and is more appropriate when the sample size is large. Both univariate and multivariate models (controlling for age group, gender, and discharge to a SNF) were fit, generating BIC values which were used to evaluate which set of predictors leads to the most appropriately specified model. For model-selection criteria such as BIC, a smaller value indicates a better model specification. Descriptive statistics included frequency tables for categorical variables and five number summaries (minimum, first quartile, median, third quartile, and maximum) for continuous variables. All analyses were stratified by calendar year. P-values <0.05 were considered significant.

Results
Percentage of elderly dying because of a fall injury increased from 2010 to 2014

Data from the WHO database show that, in the US, elderly deaths represented 83.2, 83.3, 84.1, 84.3, and 84.6% of the total deaths due to a fall injury in 2010, 2011, 2012, 2013, and 2014, respectively. The percentage of elderly people who died because of a fall injury rose annually for a total increase of 1.4% from 2010 to 2014. The proportion of elderly women who died because of a fall injury was 45.4% in 2010 and did not increase much over the 5-year period, whereas the proportion of men 65 years of age and older who died because of a fall injury was 37.8% in 2010 and increased by approximately 1.3% over the same period of time (Table 1).

Although the percentage of Americans 65–74 years old who died from a fall injury was low (11–12%), it increased by almost 1% in 5 years (Table 2). The percentage of Americans 75–84 years old who died from a fall injury decreased by 2.1%, whereas the proportion of American 85 years and older who died from a fall injury increased by 2.6% (Table 2). The WHO mortality database provides mortality information by 5 years of age increments. Although the age distribution within each age group significantly increased and/or decreased

Table 1 Fall-related death rates of elderly people from 2010 to 2014

Year	2010	2011	2012	2013	2014
Overall death rate (%)	83.2	83.3	84.1	84.3	84.6
Female death rate (%)	45.4	45.2	46.0	45.4	45.5
Male death rate (%)	37.8	38.1	38.1	38.9	39.1

Note: Data were corrected to the total number of deaths due to a fall injury.

Table 2 Fall-related death rates based on age range

Age range	2010	2011	2012	2013	2014
65–74	11.45	11.5	11.6	11.9	12.3
75–84	27.9	26.9	27	26.4	25.8
85+	43.9	45	45.5	46	46.5
Overall death rate	83.2	83.3	84.1	84.3	84.6

Note: Data were corrected to the total number of deaths due to a fall injury.

between 2010 and 2014 (chi-square=175.6, P<0.001), no disproportionate changes were observed in the percentage of patients who were 65–69 and 70–74 year olds and died as a result of a fall injury. The 2% decrease in fall-related death in the 75- to 85-year-old group was mainly due to a decrease in the percentage of 80- to 84-year olds who died as a result of a fall injury. The increase in fall-related death rate for the 85+ group was mainly associated with an increase in the fall-related death of subjects 90 years and older (Table S1).

Percentage of hospital admissions because of a fall injury increased from 2010 to 2014

Data from the NRD between 2010 and 2014 revealed that admissions due to fall injury represented more than a third of trauma admission (36.17%, 36.51%, 36.71%, 37.18%, and 38.19%) and steadily increased over time. This represents an overall 2% increase in the rate of admission of elderly for a fall injury over the same time period (2010–2014; Figure 1). When looking at the data by age range, the percentage of subjects 65–74 years old admitted for a fall injury constituted approximately half the number of subjects admitted for other reasons. The percentage of trauma patients 65–74 years of age admitted for fall injuries increased by 2.7% from 2010 to 2014. Interestingly, the rate of admission for fall injury
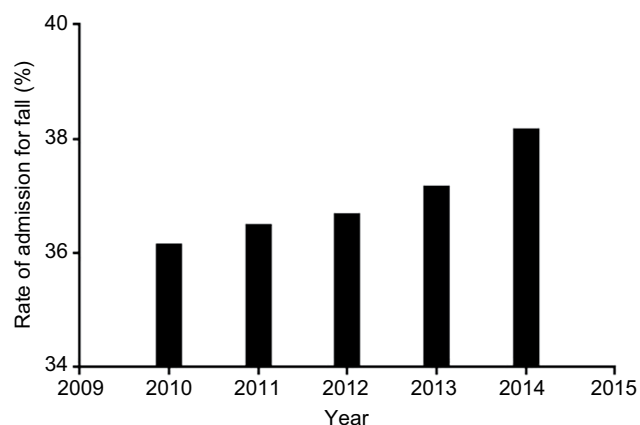

Figure 1 The rate of admission of elderly for fall injuries increased from 2010 to 2014.

in the population 75–84 years of age seemed to decrease, whereas that of the 85 years and older population was stable. It is noteworthy that the percentage of elderly 85 years and older admitted for a fall injury was twice that of elderly 85 and older admitted for other reasons (Table 3). Among the patients who were admitted following traumatic injury for other reasons, 36.1% were admitted for an injury other than a fall or poisoning, 20% were admitted for an elective procedure, 16.3% were admitted for an infectious or parasitic disease, 12.8% were admitted for diseases of the circulatory system, 6.7% for diseases of the digestive system, 6.3% for diseases of the respiratory system, and 4.3% for cancer.

The majority of patients admitted for a fall injury were women, and this percentage was higher than the percentage of women admitted for other reasons (Table 3). However, the percentage of admission of elderly women for a fall injury decreased by 2.4% between 2010 and 2014 (Table 3), indicating an increase in the percentage of men admitted for a fall during this same time frame.

When looking at the number of external injuries, most patients admitted for fall injuries presented with two or more external injuries, whereas most patients admitted for other reasons presented with one or two injuries (Table 3). Almost all patients admitted for fall injuries visited the emergency department (87.64–88.87% from 2010 to 2014; Table 3). When looking at the data using the service line codes, 59% of the fall patients were admitted for fall injuries and 34% for a medical condition, whereas 57% and 32% of the other patients were admitted for a medical and surgical procedure, respectively.

Additionally, the 2010 NRD data show that approximately 55% of patients admitted for fall injuries were transferred to SNF, intermediate care facilities, or another type of facility. Our analysis shows that this rate increased by approximately 3% between 2010 and 2014 and is twice the rate of transfer to these nursing facilities observed for patients readmitted for other reasons (Table 3). Finally, when assessing the type of insurance, we noticed that more fall patients tended to have Medicare/Medicaid insurance than non-fall trauma patients (Table 3: 93% vs 90%).

We then further characterized the types of fall incurred by elderly in each age group. As shown in Table 4, we assessed the rates of elderly 65–74 years old, 75–84 years old, and 85 years and older who were admitted for same level falls, fall from stairs, fall from height, and unspecified fall using E-codes. Most subjects were admitted for same level falls (about 35%) or unspecified falls (about 50%). Admission rates for fall from stairs or height were lower. However, the rates of admission of elderly 65–74 years old for fall from stairs or height were higher than those of elderly 75–84 years old or 85 years and older. The rate of 65–74 years old subjects admitted for a fall from stairs or step was twice that of 85 years and older subjects. The rates of 85 years and older admitted for same level falls or unspecified were higher than those of younger elderly (65–74 years of age). (Table 4).

Table 3 Characteristics of elderly trauma patients admitted for fall injuries or for other reasons

	Fall patients (%)					Non-fall trauma patients (%)				
Age range	**2010**	**2011**	**2012**	**2013**	**2014**	**2010**	**2011**	**2012**	**2013**	**2014**
65–74	**22.22**	**22.58**	**23.37**	**24.06**	**24.93**	42.3	42.85	43.78	44.82	45.6
75–84	37.87	37.38	36.58	36.13	35.59	37.47	36.89	36.11	35.34	34.65
85+	**39.91**	**40.04**	**40.05**	**39.82**	**39.48**	20.23	20.26	20.11	19.84	19.74
Female	**67.98**	**67.72**	**67.08**	**65.99**	**65.55**	52.63	52.50	52.04	51.45	51.06
Number of external injuries										
0	0	0	0	0	0	24.87	24.08	22.65	22.78	22.56
1	26.7	27.27	26.58	28.8	29.16	24.79	24.51	24.73	25.79	25.93
2	**46.21**	**47.62**	**48.55**	**48.18**	**46.87**	39.62	40.74	41.86	41.04	40.37
3	**14.47**	**13.73**	**14.07**	**13.86**	**14.69**	7.42	7.42	7.44	7.25	7.95
4	**12.62**	**11.38**	**10.8**	**9.17**	**9.28**	3.3	3.26	3.33	3.13	3.19
Emergency visit	**87.64**	**87.35**	**87.70**	**88.33**	**88.87**	66.50	67.46	68.22	69.11	70.46
All-cause 30-day readmission rate	12.4	12.3	11.8	11.3	11.3	14.22	14.28	13.87	13.46	13.44
Disposition to SNF, intermediate care	**55.59**	**56.00**	**56.57**	**57.50**	**58.51**	28.79	29.08	29.29	29.91	30.52
Insurance type										
Medicare/Medicaid	**93.41**	**93.44**	**93.64**	**93.82**	**93.75**	90.28	90.33	90.5	90.64	90.35
Other[a]	1.39	1.57	1.65	1.59	1.69	1.57	1.74	1.78	1.82	2
Private	5.2	4.99	4.71	4.59	4.57	8.15	7.93	7.72	7.54	7.66

Note: [a]Other includes self-pay, no charge, and other types of insurance. Bold values indicate the important data (showing differences compared to the non-fall patients).
Abbreviation: SNF, skilled nursing facility.

Fall patients are more likely to be readmitted for a fall within 30 days and those rates increased from 2010 to 2014

The 30-day readmission rates were relatively stable from 2010 to 2014 for the overall trauma population (13.6–12.6%, respectively). As shown in Table 3, the 30-day readmission rates for fall and non-fall patients were relatively similar and only increased by 1% over the 5-year period.

When looking at the characteristics of fall patients readmitted within 30 days of their first admission (Table 5), the percentage of fall patients 65–74 years old who were readmitted was approximately half the number of non-fall patients readmitted within 30 days of their first admission. The percentage of fall and non-fall trauma patients 65–74 years of age readmitted within 30 days increased by 4% from 2010 to 2014. Interestingly, the percentages of the fall and non-fall population 75–84 years of age readmitted within 30 days were similar and decreased by 3% and 4%, respectively, whereas those of the 85 years and older population were stable. Of note, the percentage of elderly 85 years and older in the fall group readmitted within 30 days was twice that of elderly 85 years and older in the non-fall group (Table 5).

Similar to overall admission data, the majority of fall patients readmitted within 30 days were women, and this percentage was higher than the percentage of women admitted for other reasons (Table 5). As for overall admission, the 30-day readmission data show that the percentage of elderly women who were initially admitted for a fall decreased by 2.5% between 2010 and 2014 (Table 5), suggesting an increase in the percentage of men readmitted within 30 days of their initial fall injury during this same time frame.

Similar to overall admission data, approximately 57% of fall patients readmitted within 30 days were transferred to SNFs, intermediate care facilities, or another type of facility. Our analysis shows that this rate was relatively stable over the 5-year period, but it was twice the rate of transfer to these nursing facilities observed for non-fall patients readmitted within 30 days (Table 5).

Looking at the influence of insurance type on 30-day readmission rates, univariate logistics regression with insurance as a predictor and 30-day readmission as the outcome showed significance regardless of the insurance type compared for both the fall patient and non-fall trauma patient groups (Table S2), which may be largely due to the large sample size of this study.

Table 4 Fall characteristics

Fall type	Age group	2010	2011	2012	2013	2014
Same-level fall	65–74	32.55	33.36	32.40	32.26	32.05
	75–84	34.65	34.68	33.97	33.62	33.38
	85+	34.39	34.38	34.09	33.65	33.29
Fall from stairs or step	65–74	**6.05**	**5.89**	**6.12**	**6.12**	**5.96**
	75–84	4.67	4.40	4.56	4.64	4.69
	85+	2.87	2.77	2.89	2.86	2.97
Fall from height	65–74	**12.63**	**12.11**	**12.52**	**12.08**	**12.18**
	75–84	10.13	9.80	10.18	10.11	10.09
	85+	10.48	10.04	10.27	10.23	10.10
Other or unspecified fall	65–74	48.76	48.65	48.96	49.55	49.80
	75–84	50.54	51.12	51.30	51.62	51.84
	85+	52.26	52.80	52.74	53.25	53.64

Notes: The percentage of elderly from each age group who were admitted for a same-level fall, fall from stairs, fall from height, or for an unspecified fall is presented. Bold values indicate the important data (showing differences compared to the non-fall patients).

Table 5 Characteristics of elderly fall and non-fall trauma patients readmitted within 30 days for a fall injury

	Fall patients (%)					Non-fall trauma patients (%)				
Age range	2010	2011	2012	2013	2014	2010	2011	2012	2013	2014
65–74	**21.51**	**21.78**	**23.36**	**24.36**	**25.56**	41.60	42.34	43.35	44.44	45.61
75–84	38.03	37.67	36.87	36.39	35.71	38.13	37.67	36.54	35.88	34.98
85+	40.46	40.55	39.76	39.25	38.74	20.27	19.99	20.11	19.69	19.41
Female	63.32	62.68	62.02	61.27	60.79	51.11	50.87	50.71	50.18	49.66
30-day readmission for a fall injury	**15.60**	**15.77**	**16.36**	**16.52**	**17.35**	3.59	3.48	3.55	3.67	3.82
Disposition to SNF, intermediate care	**56.71**	**56.36**	**57.32**	**57.59**	**57.94**	34.74	35.21	35.32	35.53	36.20

Note: Bold values indicate the important data (showing differences compared to the non-fall patients).
Abbreviation: SNF, skilled nursing facility.

Finally, we investigated the reasons that led to readmission within 30 days. As shown in Table 5, in 2010, 15% of the fall patients were readmitted within 30 days for a subsequent fall injury and this rate increased by approximately 2% between 2010 and 2014. This rate of 30-day readmission for a fall injury was approximately 4.5 times that observed for the non-fall trauma patients (3.5%) for whom the rate of readmission for a fall injury remained stable. Other causes of readmission within 30 days included diseases of the circulatory system (20%); injury and poisoning (18%); diseases of the respiratory system (11–12%); infectious and parasitic diseases (10–11%); diseases of the digestive system (8–9%); diseases of the genitourinary system (7–8%); and symptoms, signs, and ill-defined conditions (4–5%). Rates of readmission for these conditions were similar between the fall and non-fall patients.

Association between comorbidities and admission for fall injuries

We next sought to determine whether there were any associations between known comorbidities and admission for fall injuries in our elderly trauma population. The results of the multivariate analyses controlling for age and gender are presented in Table 6. We first calculated the OR for each comorbidity–year combination from 2010 to 2014 and then assessed whether the estimates increased or decreased during this time frame. Using a 15% cutoff for the OR as significant, we observed that patients with deficiency/anemias had, on average, a 21% increased risk of being admitted for a fall injury from 2010 to 2014. Subjects with congestive heart failure, valvular disease, and peripheral vascular diseases presented a 41%, 16%, and 23.5% increased risk of being admitted for a fall injury, respectively. Subjects with chronic pulmonary disease and pulmonary circulation disorders presented a 29.4% and 26% increased risk of being admitted for fall injury, respectively. Subjects with diabetes were at a 16% increased risk of being admitted for fall injury, and this risk doubled (34% increased risk) for subjects presenting with diabetes with chronic complications. Liver disease was associated with a 39% increased risk of being admitted for fall injury. Lymphomas, metastatic cancer, and solid tumor with no metastasis were associated with a 30.7%, 24%, and 15% increased risk of admission for fall injury, respectively. Renal failure was associated with a 44.8% increased risk of being admitted for a fall injury. Obesity was associated with a 15.5% increased risk of being admitted for a fall injury. Patients presenting with psychosis presented a 15.5% increased risk of being admitted for a fall injury. Drug abuse

Table 6 Association between comorbidities and admission for fall injury

Comorbidity (% of our fall population)	2010		2011		2012		2013		2014	
	OR	P	OR	P	OR	P	OR	P	OR	P
Deficiency anemias (24.92%)	1.20921	<0.0001	1.18173	<0.0001	1.18726	<0.0001	1.2284	<0.0001	1.23712	<0.0001
Congestive heart failure (15.32%)	1.39118	<0.0001	1.41201	<0.0001	1.38572	<0.0001	1.43082	<0.0001	1.42568	<0.0001
Valvular disease (8.79%)	1.16294	<0.0001	1.15168	<0.0001	1.1349	<0.0001	1.17816	<0.0001	1.17328	<0.0001
Peripheral vascular disorders (8.29%)	1.2371	<0.0001	1.23922	<0.0001	1.2252	<0.0001	1.23505	<0.0001	1.24017	<0.0001
Chronic pulmonary disease (20.87%)	1.30533	<0.0001	1.26653	<0.0001	1.29833	<0.0001	1.28608	<0.0001	1.31553	<0.0001
Pulmonary circulation disorders (3.99%)	1.23126	<0.0001	1.24406	<0.0001	1.26869	<0.0001	1.30715	<0.0001	1.25473	<0.0001
Diabetes uncomplicated (21.31%)	1.17085	<0.0001	1.14892	<0.0001	1.15819	<0.0001	1.15462	<0.0001	1.17443	<0.0001
Diabetes with chronic complications (5.04%)	1.31896	<0.0001	1.32346	<0.0001	1.33086	<0.0001	1.36065	<0.0001	1.37608	<0.0001
Liver disease (1.64%)	1.45396	<0.0001	1.31132	<0.0001	1.36085	<0.0001	1.36728	<0.0001	1.45646	<0.0001
Lymphomas (0.92%)	1.26437	<0.0001	1.21874	0.0001	1.35072	<0.0001	1.31511	<0.0001	1.38847	<0.0001
Metastatic cancer (1.50%)	1.25664	<0.0001	1.29912	<0.0001	1.16748	0.0001	1.19411	<0.0001	1.2804	<0.0001
Solid tumor without metastasis (2.10%)	1.15257	<0.0001	1.13184	0.0003	1.1485	<0.0001	1.1081	0.0021	1.22306	<0.0001
Renal failure (16.92%)	1.45879	<0.0001	1.461	<0.0001	1.42964	<0.0001	1.44849	<0.0001	1.44516	<0.0001
Obesity (5.81%)	1.14048	<0.0001	1.17409	<0.0001	1.16739	<0.0001	1.14601	<0.0001	1.15152	<0.0001
Psychosis (4.54%)	1.12269	<0.0001	1.14917	<0.0001	1.17979	<0.0001	1.10076	<0.0001	1.22373	<0.0001
Drug abuse (0.69%)	1.22106	0.0046	1.31282	<0.0001	1.19825	0.0024	1.24906	<0.0001	1.47611	<0.0001
Rheumatoid arthritis/collagen vascular diseases (3.95%)	1.16004	<0.0001	1.1212	<0.0001	1.06695	0.0163	1.1528	<0.0001	1.07257	0.0043

Notes: The numbers in parentheses represent the weighted average percentage of our fall population (patients ≥65 admitted for trauma) that presented with each comorbidity.

increased the risk of being admitted for a fall injury by 29% on average in the elderly population. Of note, the association between drug abuse and risk of being admitted for a fall injury increased from 22% in 2010 to 47% in 2014. Finally, patients presenting with rheumatoid arthritis/collagen vascular diseases presented a 16% increased risk of fall in 2010 which decreased to a 7.5% risk in 2014.

Discussion

Nationwide, falls are the leading cause of injury and injury-related death in people 65 years of age and older.[6,8] This study is the first to investigate death, admission, and 30-day readmission for falls in elderly patients (≥65) following a traumatic injury at the national level over a period of 5 years (2010–2014) by using the NRD and WHO mortality database.

Previous studies showed that approximately a third of the elderly population fall at least once per year.[12,19,20] Similarly, our data indicate that admissions for fall injuries represent more than a third of admission for traumatic injuries. Moreover, in the elderly population, both fall injury-related mortality and admission rates for falls increased by 1.4% and 2%, respectively, from 2010 to 2014.

Many previous research studies indicated that falls were more common in women than in men, with women accounting for the majority of fall-related emergency room visits.[8,21] However, our study is noteworthy in that fall-related mortality rates of elderly women remained stable. Similarly, although the majority of patients admitted for a fall injury were women, fall-related admission rates of elderly women decreased by 2.4%, suggesting that readmission rates of elderly men increased from 2010 to 2014. This is similar to a trend that was observed in another study examining falls in the elderly that found that men comprised 50% of total falls, 46.8% of ground-level falls, and 69.6% of falls from heights.[22]

Both fall-related mortality and admission of patients 65–74 years old increased (1% and 2.7%, respectively). While counterintuitive, there are two interrelated hypotheses that potentially account for this. First, less than half of the elderly population that experiences a fall seek medical attention or report their fall to their physician; therefore, the observed difference may be related to the severity of the fall and the injuries sustained.[11] This increase in injury severity that led the patients to seek medical care might be associated with the fact that subjects 65–74 years old are healthier and more likely to engage in more strenuous physical activity, including climbing. Our data support this hypothesis as the rates of 65- to 74-year-old subjects admitted for a fall from height or stairs were higher than those of subjects 75 years and older.

The fall-related admission rates of subjects 65–74 years was approximately half that of the same population admitted for other traumatic injuries. Interestingly, fall-related mortality and admission rates decreased for the 75–84 years population (2.1% and 2.3%, respectively). However, whereas fall-related mortality rates increased (2.7%) for the population 85 years and older, fall-related admission rates were relatively stable over the 5 years, but twice that of patients 85 years and older admitted for other traumatic injuries. These data suggest that the two groups the most at risk of being admitted for fall injury are the 65–74 years and the 85 and older patient groups and, therefore, these groups could be targets for prevention programs.

Previous studies looking at readmission following trauma using single institution, multicenter, or statewide data found readmission rates ranging from 4.3% to 13.7%.[13] Only two studies focused on older adults and found readmission rates of 7.9% and 13.7%, respectively. However, neither of these studies looked specifically for readmission after falls.[13,23] Ayoung-Chee et al found a 30-day readmission rate of 13% following ground-level falls in patients 65 years of age and older.[4] Using the NRD, we observed similar overall 30-day readmission rates for non-fall trauma patients and for fall patients over the 5-year period analyzed (Table 3). However, our data provide additional information. In fact, the percentage of fall patients readmitted for a subsequent fall is steadily increasing, as evidenced in our analysis of the NRD database (3% increase over 5 years), and is 4.5 times that observed for non-fall patients. These results clearly show that once an elderly person falls, he/she is prone to fall again. Our results agree with previous studies showing that approximately one third of older adults fall at least once per year and that half of this cohort experiences multiple falls.[12,19,20,24]

There have been many efforts to create effective fall-prevention programs; however, most of these have fallen short due to a failure of integration of screening into primary care practices, likely due to providers not feeling confident about their ability to assess fall risk. The CDC developed a program called Stopping Elderly Accidents, Death, and Injuries (STEADI) that is designed to provide primary care providers with the tools to prevent fall risk.[25] The program strives to teach physicians about risk factors for falls, screen patients for fall risk, and implement a treatment plan to prevent falls. The full effects of these efforts have not been fully seen.

Prevention of falls is essential as health-care costs associated with falls and readmissions from falls are not inconsequential. Additional analysis revealed that almost 90% of the patients admitted for a fall injury visited the emergency

room, and more than 55% (increasing by 3% in 5 years) were transferred to SNFs, intermediate care facilities, or another type of facility, which is twice the rate of transfer to these types of facilities observed for patients admitted for other traumatic injuries, resulting in high health-care cost. A study in 2015 estimated that the total cost related to both fatal and non-fatal fall injuries was $50.0 billion. Fatal falls alone accounted for $754 million, and non-fatal falls accounted for 6.0% of Medicare expenditures and 8.0% of Medicaid expenditures.[10]

Our study presents some limitations, starting with its retrospective nature. All findings are national estimates generated from the NRD sample; the accuracy of the estimates and their associated variances depend on the weighting methods developed by the Agency for Healthcare Research and Quality. Additionally, the patient linkage numbers do not track the same patient across years of the NRD and the hospital identifiers do not track the sampled hospitals across years of the NRD. Therefore, each year of the NRD was considered as a separate sample. Moreover, this prevents the calculation of 30-day readmission rates for patients admitted to the hospital in the month of December. An additional limitation is that the database is not positioned to assess patient medications, some of which are known to increase the risk of fall in elderly,[26] outpatient care, or other factors that influence patients' health and health care during transitions from hospital to home. A final limitation of the NRD and, therefore, this study as we conducted it using data from 2010 to 2014 prior to the change to ICD-10 coding, is that we are unable to fully determine whether the readmissions are related to new falls or sequela of the initial fall. We are able to determine if the readmissions were elective (for definitive repair of a fracture sustained during an initial fall for example) or emergent (either a new fall or a sequela/complication of the initial fall), but not if they are definitively different occurrences.

Despite these limitations, this study teaches us important lessons about the frequency of falls, readmissions related to falls, and mortality from falls in the elderly. Using this knowledge, we must move forward in improving the care of the elderly trauma patient. Falls and mortality related to falls are increasing across the elderly population who present with traumatic injuries (both initial falls and other traumas). With this knowledge, we must shift our focus on how to prevent these deaths and better care for elderly patients who present with traumatic injuries. Prevention programs such as STEADI may be critical to decreasing the number of patients who fall and are readmitted with falls and, perhaps, the most important part of any program is the ability to determine which patients are at risk. By determining those who are at risk for readmission following falls and those at risk for repeat falls or other injuries, we can better devise treatments plans which serve to help prevent injury. Only through better understanding of why patients fall and are readmitted following injury can we create logical prevention programs that serve to help older patients. Through these efforts, we will also be able to decrease the costs related to repeat admissions for injuries that could be prevented.

Conclusion

This is the first study investigating fall-related death, admissions, and readmissions longitudinally at the national level. Our results clearly show a steady increase in the admission rate of elderly patients for fall injuries, which is paralleled by an increase in death rates from 2010 to 2014. Whereas the 30-day readmission rate of fall and non-fall patients remained relatively stable, the incidence of readmission for a subsequent fall is increasing among trauma patients initially admitted for a fall. Based on the NRD data, elderly individuals 65–74 years old and 85 years and older are the most at risk of being admitted for fall injuries.

Acknowledgments

Author contributions

Colette Galet contributed to the design of the study, analysis and interpretation of the data, and wrote the manuscript. Yunshu Zhou contributed to the design of the study, analyzed the data, and critically revised the manuscript for important intellectual content. Patrick Ten Eyck contributed to the design of the study, analyzed the data, and critically revised the manuscript for important intellectual content. Kathleen S Romanowski conceptualized and designed the study, acquired the data, participated in data analysis and interpretation, and wrote and critically revised the manuscript for important intellectual content. All authors contributed to data analysis, drafting and revising the article, gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

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Supplementary materials

Table S1 Fall-related death: age distribution

Age group	2010	2011	2012	2013	2014	Total
65–69	1,184	1,311	1,471	1,577	1,690	7,233
	5.47	**5.72**	**6.08**	**6.19**	**6.25**	
70–74	1,805	1,838	1,861	2,009	2,248	9,761
	8.34	**8.03**	**7.69**	**7.89**	**8.31**	
75–79	2,801	2,755	2,900	3,044	3,379	14,879
	12.94	**12.03**	**11.99**	**11.95**	**12.49**	
80–84	4,448	4,632	4,876	4,942	4,878	23,776
	20.55	**20.23**	**20.16**	**19.41**	**18.04**	
85–89	5,577	5,921	6,059	6,395	6,576	30,528
	25.76	**25.85**	**25.05**	**25.11**	**24.32**	
90–95	3,955	4,386	4,742	5,149	5,705	23,937
	18.27	**19.15**	**19.60**	**20.22**	**21.10**	
95+	1,880	2,058	2,281	2,348	2,568	11,135
	8.68	**8.99**	**9.43**	**9.22**	**9.50**	
Total	21,650	22,901	24,190	25,464	27,044	121,249

Note: The raw number of deaths by 5-year increment is presented followed by the percentage.

Table S2 Influence of insurance type on 30-day readmission

	2010		2011		2012		2013		2014	
Fall patients	Chi-squared	*P*-value	Chi-squared	*P*-value	Chi-squared	*P*-value	Chi-squared	*P*-value	Chi-squared	*P*-value
Private insurance vs Medicare/Medicaid	76.69	<0.0001	45.84	<0.0001	30.23	<0.0001	43.33	<0.0001	41.56	<0.0001
Other vs Medicare/Medicaid	65.05	<0.0001	46.43	<0.0001	43.41	<0.0001	44.57	<0.0001	38.45	<0.0001
Overall effect (Type 3)	149.82	<0.0001	95.61	<0.0001	76.35	<0.0001	91.22	<0.0001	82.24	<0.0001
Non-fall patients										
Private insurance vs Medicare/Medicaid	372.61	<0.0001	232.92	<0.0001	197.84	<0.0001	247.29	<0.0001	241.04	<0.0001
Other vs Medicare/Medicaid	133.38	<0.0001	120.16	<0.0001	151.58	<0.0001	139.76	<0.0001	130.04	<0.0001
Overall effect (Type 3)	527.87	<0.0001	362.94	<0.0001	362.43	<0.0001	400.33	<0.0001	380.91	<0.0001