

Cost of U.S emergency department and inpatient visits for fall injuries in older adults

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ABSTRACT

Background: Falls are a leading cause of injury and hospital readmissions in older adults. Understanding the distribution of acute treatment costs across inpatient and emergency department settings is critical for informed investment and evaluation of fall prevention efforts.

Methods: This study used the 2016–2018 National Inpatient Sample and National Emergency Department Sample. Annual treatment cost of fall injury among adults 65 years and older was estimated from charges, applying cost-to-charge and professional fee ratios. Weighted multivariable generalized linear models were used to separately estimate cost for inpatient and emergency department (ED) setting by injury type and individual demographic and health characteristics after adjusting for payer and hospital level characteristics.

Results: Older adults incurred an estimated 922,428 inpatient and 2.3 million ED visits annually due to falls with combined annual costs of \$19.8 billion. Over half of inpatient visits for fall injury were for fracture. Notably, 23% of inpatient visits were for fractures other than hip fracture and 14% of inpatient visits were for multiple fractures with costs totaling \$3.4 billion and \$2.5 billion, respectively. Annual ED costs were driven by superficial injury totaling \$1.5 billion. Cost of ED visits were higher for adults 85 years and older (adjusted cost ratio (aCR): 1.11, 95% Confidence Interval (CI): 1.11–1.12) and those with dementia (aCR: 1.14, 95% CI: 1.13–1.15). Higher inpatient and ED visit cost was also associated with high-energy falls and discharge to post-acute care.

Conclusion: The study found that more than 3 million older adults in the United States seek hospital care for fall injuries annually, a major concern given increasing capacity strain on hospitals and EDs. The \$20 billion in annual acute treatment costs attributed to fall injury indicate an urgent need to implement evidence-based fall prevention interventions and underscores the importance of newly launched ED-based fall prevention efforts and investments in geriatric emergency departments.

Introduction

Falls are the leading cause of injury in older adults [1]. Each year, approximately 3 million older adults are treated for injurious falls in U.S. emergency departments and more than 800,000 are hospitalized [2]. Fall injuries not only lead to substantial morbidity and mortality, but have significant financial implications comprising an estimated \$50 billion dollars annually in health care spending for adults 65 years and older [3,4]. While numerous studies have estimated the economic burden of falls, [4–12] little is known about how the costs of acute medical care for falls differ by injury type and medical care setting. Given that fall injury and fall related healthcare utilization are projected

to rise [13], understanding factors affecting cost of treating fall injury among older adults by setting (inpatient hospital vs. emergency department) will be important for guiding fall prevention and monitoring efforts as well as planning for future care needs in the context of population aging.

Among older adults who fall, over half receive medical care in the hospital; 34% are treated and released from the emergency department and 19% are admitted for their injuries [14]. Those who are admitted tend to be older and have more severe injury, often involving fracture [14]. The cost and outcomes of fall-related hip fractures has been a longstanding topic of study [15–19], however little is known about the treatment cost of other fall related fracture types (e.g., humerus, ankle)

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which are becoming more prevalent among older adults [20,21]. Fall mechanism is another under-studied aspect that may have important implications for cost as well as clinical care management. While most older adults' fall injuries are from low level falls, falls from height are increasing in older men and women potentially leading to more severe injury [20] though the cost of emergency department and inpatient care by fall mechanism has not been studied. Acute care cost by injury type and care setting are relevant to payment initiatives which incentivize clinicians to coordinate care across care settings and could motivate hospitals to align resources and partner with clinicians and community-based organization on improving care pathways and implementing fall prevention interventions. This is especially important because fall injuries are the leading hospital readmission diagnosis among older adults initially hospitalized for a fall. [22]

Given the importance of acute care cost for the design and implementation of fall injury prevention and treatment initiatives, we describe the frequency and costs of inpatient and emergency department visits for fall injuries among older adults in the United States using 2016–2018 data from the National Inpatient Sample and National Emergency Department Sample. We specifically focus on cost differences by injury type, fall mechanism, and treatment setting, with attention to variation in cost by demographic and health characteristics.

Methods

Study design and setting

Data were drawn from the 2016–2018 National Inpatient Sample (NIS) and National Emergency Department Sample (NEDS) a publicly available administrative databases in the United States. The NIS contains all-payer discharge level data on a nationally representative sample of inpatient stays encompassing more than 97% of the U.S. population and approximately 96% of discharges from U.S community hospitals [23]. The sampling frame of NEDS is a 20% stratified sample of U.S hospital owned EDs which contribute to HCUP, representing approximately 85% of ED encounters nationally. [24] The 2016–2018 NEDS contains information from 33.5 million ED visits from 984 hospitals across 38 states.

In the NIS data set, ED charges are included only for ED services provided within the same facility. If a patient was transferred from the ED to a separate inpatient facility, the NIS data would only report the inpatient cost and would not include the ED cost from the originating facility. Therefore, to ensure nonoverlapping, comprehensive visit counts and cost estimates of both ED and inpatient visits, we included patients who were transferred from the ED to other facilities in our ED treat and release estimates, as previously described [25].

Selection of participants

Our cohort included adults 65 years and older with an ED treat and release or an inpatient visit with a primary or secondary fall diagnosis defined as International Classification of Disease, Tenth Edition Clinical Modification (ICD-10-CM) codes W00-W19. We excluded visits with no specified injury diagnosis as well as pathologic fractures and collapsed vertebrae or other lumbar degenerative diagnoses which are caused by underlying disease yielding an estimated 2767,284 inpatient visits and 7008,289 ED treat and release visits (Fig. 1).

Measurements

Patient characteristics

Sociodemographic information included age (categorized 65–74; 75–84 and ≥ 85), gender, and race (White, Black, Hispanic, and other or unknown). Dementia diagnosis was defined using ICD-10 codes associated with Alzheimer's disease or related disorders diagnoses [26,27]. Discharge status categories included routine discharge (**discharge to home or self care**); transfer to short term hospital; home with home health; against medical device; died in hospital; or transfer to skilled nursing facility (SNF), intermediate care, or another type of facility.

Injury type and mechanism

Injury type was classified into 6 mutually exclusive groups, adapted from the Barell injury diagnosis matrix [28]: (1) superficial injuries; (2) hip fracture; (3) non-hip fracture which includes all other fractures of the upper and lower extremity, back, pelvis, torso, and head and neck; (4) multiple fractures defined as having a fracture in more than one body region; (5) sprains and dislocations; and (6) traumatic brain injury. Injury mechanism was classified as high or low energy fall. High energy was defined as injuries with ICD-10 codes corresponding with high falls such as from stairs or a ladder and low energy defined as injuries with ICD-10 codes corresponding with falls from standing height [20].

Primary payer and hospital characteristics

Primary payer included Medicare, Medicaid, and private (HMO, self-pay, and other). Hospital characteristics included geographic region (Northeast, Midwest, South and West), urban versus rural location, and teaching hospital status [24,29]. From the NEDS we include hospital-level trauma designation. [29]

Outcome

Cost estimates were derived from charges representing facility fees for each encounter. Charges were converted to costs using cost-to-charge ratios provided by HCUP that reflect the average reimbursement to a

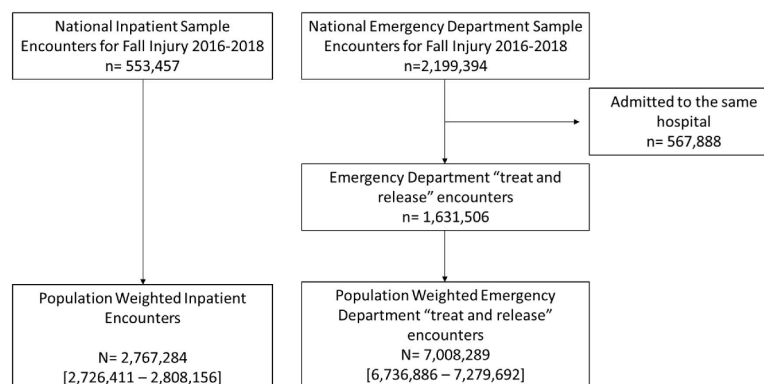


Fig. 1. Sample selection of inpatient encounters and emergency department “treat and release” encounters for fall injury among adults 65 years and older from 2016 to 2018 using the Health Care Utilization Project National Inpatient Sample and National Emergency Sample data. Encounters with an ICD-10 external cause of injury code for fall (W00-W19) were included.

given facility by all payers (insurers) each year using a subset of full accounting of the discharge data [30]. The average cost-to-charge ratios for the encounters we observed was 0.292 for the NIS and 0.1697 for the NEDS. Next, as HCUP charges only includes facility fees, not professional fees (i.e. physicians service fee), we used an approach described in Peterson et al 2015 that estimates average professional fee ratios (relative to facility charges) for inpatient stays and treat and release ED visits. [31] Estimates of average professional fee ratios from 2012 were used (the most recent year of data available), partitioned by facility type (IP/ED) and payer (Medicaid or not Medicaid), and applied to all costs to better reflect payers' actual costs. The average professional fee ratios were 1.264 for NIS and 1.286 for NEDS. All costs were adjusted to and presented in 2018 dollars using the Medical Consumer Price Index. Encounter costs were computed by multiplying the observed facility charge, the cost to charge ratio, the facility-specific average professional fee ratios, and an inflation adjustment to standardize estimates to 2018 dollars. Eq. (1) details the various adjustments to estimate each encounter cost.

$$\text{EncounterCost} = \text{ObservedFacilityCharge} * \text{Hospital} / \text{FacilityType} / \text{YearSpecificCCR} * \text{FacilityTypePFR} * \text{InflationAdjustmentto2018Dollars} \quad (0.1)$$

Analysis

We first estimated the number of inpatient and ED visits due to fall injury, and total and per-visit average costs in each year using discharge weights provided by the NIS and NEDS. Weighted generalized linear models (GLMs), with gamma error distributions and log links were then used to estimate associations between patient and injury characteristics and per visit costs by setting. We developed multivariable models that adjusted for primary payer and hospital characteristics. In these GLMs, each covariate coefficient describes the expected difference in log cost relative to the reference group for that covariate. Coefficients were exponentiated for interpretability, describing each as a cost ratio relative to the reference group. The data used for these analyses are fully deidentified and not collected for the sole purpose of this study. Therefore, this project is not considered human subjects research and did not require institutional review. The data were analyzed using STATA version 15.1 (College Station, TX).

Table 1

Estimated Number and Cost of Inpatient and Emergency Department Visits for a Fall Injury among Older Adults in the United States 2016–2018.

	2016	2017	2018	Annual Average
Number of Visits (95 % CI) (millions)				
Inpatient	880,914 (843,694–918,135)	923,669 (883,915–963,424.3)	962,699 (920,888–1004,511)	922,428 (900,442–944,414)
ED “treat and release”	2233,728 (2061,236–2406,220)	2413,074 (2234,247–2591,900)	2361,487 (2219,937–2503,038)	2336,096 (2240,829–2431,363)
Average Cost per Visit (95 % CI)				
Inpatient	\$18,670 (\$18,390–\$18,951)	\$18,613 (\$18,315–\$18,912)	\$18,686 (\$18,416–\$18,959)	\$18,658 (\$18,491–\$18,823)
ED “treat and release”	\$1064 (\$1037–\$1090)	\$1119 (\$1090–\$1148)	\$1150 (\$1118–\$1182)	\$1112 (\$1093 – \$1131)
Total Cost (95 % CI) (billions)				
Inpatient	\$16.4 (\$15.7–\$17.2)	\$17.2 (\$16.4–\$18)	\$18.0 (\$17.2–\$18.8)	\$17.2 (\$16.8–\$17.7)
ED “treat and release”	\$2.38 (\$2.18–\$2.57)	\$2.70 (\$2.49–\$2.91)	\$2.72 (\$2.54–\$2.89)	\$2.60 (\$2.48 – \$2.71)
Total Cost (billions)	\$18.78	\$19.90	\$20.72	\$19.8

Results

An estimated 922,428 (95% CI: 900,442–944,414) inpatient visits and 2.3 million (95% CI: 2.2–2.4) ED visits for fall injuries were incurred by older adults, on average, each year during the 2016–2018 observation period (Table 1). The estimated annual average cost for fall injuries was \$18,658 (95%CI: 18,491–18,823) per inpatient visit and \$1112 (95%CI: 1093–1131) per ED visit, with total annual costs estimated to exceed \$17 billion and \$2 billion, respectively for a combined total cost of \$19.8 billion dollars.

Inpatient and ED visit frequency and cost by demographic, injury, and health characteristics

Inpatient visits and associated total costs of fall injury were concentrated among the oldest age groups (ages 75–84 and 85+). Inpatient visits were primarily due to low-energy injuries (accounting for 90.9%), and injuries involving hip (29.8%) and other (22.7%) frac-

tures totaling \$5.95 billion and \$3.4 billion, respectively (Table 2). Nearly 2/3 (61.6%) of hospitalized older adults with injurious falls were discharged to a skilled nursing or other intermediate setting. In contrast, ED visits and associated average total costs for fall injury were concentrated among adults in the younger age groups (65–74; 75–84). ED visits were primarily due to low-energy injuries (89.5%) and superficial injuries (60.8%), and other, non-hip fractures (21.7%) totaling \$1.48 and \$0.59 billion, respectively. The majority (87.4%) of older adults were routinely discharged home from the ED.

Variability in inpatient and ED visit cost by demographic, injury and health characteristics

Acute treatment costs of fall injuries varied significantly by socio-demographic characteristics, injury type, and care setting (Table 3). Inpatient visit costs were lower among those who were older, female, white, with a dementia diagnosis, and low energy falls. Relative to superficial injuries, inpatient visit cost was highest for hip fracture (RR: 1.38 (95%CI: 1.37–1.39), multiple fracture (RR: 1.22 (95%CI: 1.21–1.23), and traumatic brain injury (RR: 1.21 (95%CI: 1.19–1.22).

Table 2

Hospitalizations, Cost and Annual Spending by Sociodemographic and Injury Characteristics, 2016–2018.

	Inpatient (IP) <i>N</i> = 2767,284			Emergency Department (ED) <i>N</i> = 7008,289		
	Average Annual IP Stays	Average Per Visit Cost (95 % CI)	Average Annual Spending (Billions)	Average Annual ED Stays	Average Per Visit Cost (95 % CI)	Average Annual Spending (Billions)
Overall	922,428	\$18,658	\$17.2	2336,096	\$1112	\$2.60
Age						
65–74	244,291 (26.5 %)	\$ 20,708 (20,503, 20,913)	\$5.06 (4.92–5.20)	847,213 (36.3 %)	\$1013 (995, 1031)	\$0.86 (0.82–0.90)
75–84	323,420 (35.1 %)	\$ 19,015 (18,854, 19,175)	\$6.15 (5.99–6.31)	795,154 (34.0 %)	\$1130 (1111, 1149)	\$0.89 (0.86–0.94)
85+	354,716 (38.5 %)	\$ 16,919 (16,783, 17,055)	\$6.00 (5.85–6.16)	693,729 (29.7 %)	\$1210 (1189, 1232)	\$0.84 (0.80–0.88)
Gender						
Male	326,088(35.3 %)	\$ 20,283 (20,084, 20,482)	\$6.61 (6.43–6.80)	788,391 (33.8 %)	\$1139 (1119, 1159)	0.89 (0.86–0.94)
Female	596,339(64.6 %)	\$ 17,768 (17,637, 17,900)	\$10.6 (10.33–10.86)	1547,705 (66.3 %)	\$1097 (1079, 1116)	1.70 (1.62–1.78)
Race						
White	754,526(81.8 %)	\$ 18,171 (18,032, 18,311)	\$13.71(13.35–14.07)	NA	NA	NA
Black	41,660(4.5 %)	\$ 20,006 (19,613, 20,399)	\$0.83 (0.79–0.87)			
Hispanic	55,409(6.0 %)	\$ 20,709 (20,270, 21,148)	\$1.15 (1.08–1.22)			
Other/unknown	70,831(7.7 %)	\$ 21,434 (21,017, 21,851)	\$1.52 (1.42–1.62)			
Dementia Diagnosis						
No	680,850(73.8 %)	\$ 18,838 (18,689, 18,988)	\$12.83(12.50–13.16)	2101,141 (89.9 %)	\$1081 (1063, 1099)	\$2.27 (2.17–2.37)
Yes	241,578(26.2 %)	\$ 18,147 (17,979, 18,315)	\$4.38 (4.27–4.50)	234,955 (10.1 %)	\$1382 (1352, 1411)	\$0.32 (0.31–0.34)
Injury						
Superficial injury	179,575(19.5 %)	\$15,260 (15,108, 15,413)	\$2.74 (2.67–2.81)	1420,657 (60.8 %)	\$1044 (1028, 1061)	1.48 (1.42–1.55)
Hip Fracture	275,285(29.8 %)	\$21,607 (21,452, 21,762)	\$5.95 (5.81–6.09)	40,334 (1.7 %)	\$1358 (1320, 1396)	0.05 (0.05–0.06)
Multiple Fractures	126,230(13.6 %)	\$19,569 (19,342, 19,796)	\$2.47 (2.39–2.55)	115,188 (4.9 %)	\$1529 (1486, 1572)	0.18 (0.17–0.18)
Other Fractures	209,463(22.7 %)	\$16,281 (16,126, 16,435)	\$3.41 (3.32–3.50)	507,286 (21.7 %)	\$1164 (1141, 1186)	0.59 (0.56–0.62)
Sprain/dislocation	10,695(1.2 %)	\$15,563 (15,116, 16,011)	\$0.17 (0.16–0.17)	163,766 (7.0 %)	\$824 (809, 839)	0.13 (0.13–0.14)
Traumatic Brain Injury	121,180(13.1 %)	\$20,421 (20,093, 20,749)	\$2.47 (2.37–2.58)	88,865 (3.8 %)	\$1762 (1701, 1823)	0.16 (0.15–0.16)
Fall Mechanism						
Low energy	838,956 (90.9 %)	\$ 18,412 (18,272, 18,553)	\$15.45(15.06–15.83)	2091,100 (89.5 %)	\$1104 (1086, 1122)	2.31 (2.21–2.41)
High energy	83,472 (9.1 %)	\$ 21,118 (20,813, 21,422)	\$1.76 (1.70–1.83)	244,996 (10.5 %)	\$1174 (1149, 1200)	0.29 (0.28–0.30)
Discharge Disposition						
Routine	466,459 (16.8 %)	\$14,100 (13,943, 14,257)	\$2.19 (2.13–2.26)	2040,842(87.4 %)	\$1005 (988, 1023)	2.05 (1.96–2.15)
Short-term Hospital	62,685 (2.2 %)	\$16,951 (16,469, 17,433)	0.35 (0.34–0.37)	100,901 (4.3 %)	\$1736 (1700, 1773)	0.18 (0.17–0.18)
SNF, ICF, Other	1703,839 (61.6 %)	\$20,109 (19,949, 20,269)	\$11.42(11.13–11.72)	152,847 (6.5 %)	\$1790 (1722, 1858)	0.27 (0.26–0.29)
Home with Home Health	438,625 (15.8 %)	\$16,380 (16,200, 16,560)	\$2.40 (2.33–2.46)	24,194 (1.0 %)	\$2761 (2632, 2891)	0.06 (0.06–0.07)
Against Medical Advice	11,790 (0.4 %)	\$14,093 (12,513, 15,673)	\$0.06 (0.04–0.07)	11,487 (0.)	\$1209 (1175, 1242)	0.01 (0.01–0.01)
Died in Hospital	82,155 (2.9 %)	\$28,609 (27,980, 29,237)	\$0.78 (0.75–0.82)	1999 (0 %)	\$2633 (2428, 2839)	0.01 (0.0–0.01)
Unknown	1735 (0.1 %)	\$15,716 (12,909, 18,522)	\$0.01 (0.00–0.02)	3827 (0 %)	\$2591 (1718, 3463)	0.01 (0.01–0.01)
Year						
2016	31.8	\$18,670	\$16.4 (\$15.7–\$17.2)	744,576 (31.9 %)	\$1165 (1037, 1091)	\$2.38 (2.18–2.57)
2017	33.4	\$18,390–18,951)	\$17.2 (\$16.4–\$18)	804,358 (34.4 %)	\$1119 (1090, 1148)	\$2.72 (2.54–2.89)
2018	34.8	\$18,614	\$18.0 (\$17.2–\$18.8)	787,162 (33.7%)	\$1150 (1118, 1182)	\$2.60 (2.48 - 2.71)

Annual average visits x average per visit cost= average annual spending.

Table 3
Factors Associated with Per-Visit Inpatients and Emergency Department Cost 2016–2018.

	Inpatient N = 2767,284 Adjusted Cost Ratio (95 % CI)	p-value	Emergency Department N = 7008,289 Adjusted Cost Ratio (95 % CI)	p-value
Age				
65–74	Ref	—	Ref	
75–84	0.89 (0.88–0.89)	<0.001	1.09 (1.08–1.09)	<0.001
85+	0.77 (0.76–0.78)	<0.001	1.11 (1.11–1.12)	<0.001
Gender				
Male	Ref	<0.001	Ref	—
Female	0.88 (0.88–0.89)	<0.001	0.96 (0.96–0.97)	<0.001
Race				
White	Ref	—		
Black	1.10 (1.08–1.11)	<0.001	NA	NA
Hispanic	1.10 (1.08–1.12)	<0.001		
Other/ unknown	1.11 (1.09–1.13)	<0.001		
Dementia				
Diagnosis				
No	Ref	—	Ref	—
Yes	0.97 (0.96–0.97)	<0.001	1.14 (1.13–1.15)	<0.001
Injury				
Superficial	Ref	—	Ref	—
Hip Fracture	1.38 (1.37–1.39)	<0.001	0.95 (0.93–0.98)	<0.001
Multiple	1.22 (1.21–1.23)	<0.001	1.31 (1.29–1.34)	<0.001
Fractures				
Other Fractures	1.05 (1.04–1.06)	<0.001	1.07 (1.06–1.08)	<0.001
Sprain/ dislocation	0.99 (0.97–1.02)	<0.001	0.84 (0.83–0.85)	<0.001
Traumatic				
Brain Injury	1.21 (1.19–1.22)	<0.001	1.45 (1.42–1.48)	<0.001
Fall Mechanism				
Low energy			Ref	—
High energy	1.08 (1.07–1.09)	<0.001	1.07 (1.06–1.07)	<0.001
Discharge				
Disposition				
Routine	Ref	—	Ref	—
Short-term	1.20 (1.17–1.23)	<0.001	1.63 (1.60–1.66)	<0.001
Hospital				
SNF, ICF, Other	1.46 (1.45–1.48)	<0.001	1.63 (1.58–1.66)	<0.001
Home with	1.19 (1.18–1.21)	<0.001	2.59 (2.48–2.71)	<0.001
Home Health				
Against Medical	0.88 (0.80–0.96)	0.004	1.18 (1.15–1.21)	<0.001
Advice				
Died in Hospital	2.0 (1.96–2.04)	<0.001	2.11 (1.99–2.24)	<0.001
Unknown	1.15 (0.98–1.35)	0.093	2.47 (1.81–3.36)	<0.001

Adjusted for hospital region, bed size, teaching type, primary payor, year.

Notably, costs were 2 times higher for older adults who died in the hospital compared with those routinely discharged (RR: 2.0 95%CI: 1.96–2.04) and visit costs for non-fatal injuries were 46% higher for older adults discharged to post- acute care (RR: 1.46 95%CI: 1.45–1.48). The costs for ED visits were lower for those who were younger, female, without a dementia diagnosis, and who incurred a low energy fall. Relative to superficial injuries, ED costs were lower for those who incurred a sprain (RR: 0.84 (95%CI: 0.83–0.85) and higher for those who incurred multiple fracture (RR: 1.31 (95%CI: 1.29–1.34), other (non-hip) fractures (RR: 1.07 (95%CI: 1.06–1.08), and traumatic brain injury (RR: 1.45 (95%CI: 1.42–1.48).

Total inpatient and ED cost by injury type, gender, and age

Finally, we examine acute treatment costs of fall injuries by age group, gender, and fall injury type by inpatient (Fig. 2a) and ED setting (Fig. 2b). Average annual inpatient costs of fall related fracture (i.e., hip fracture, multiple fracture, and other fracture) were approximately twice as high for women than men in any age group, consistent with higher number of visits by women as compared to men. Fractures comprised 57% of total inpatient cost in men (\$3.8 billion) and 75% of

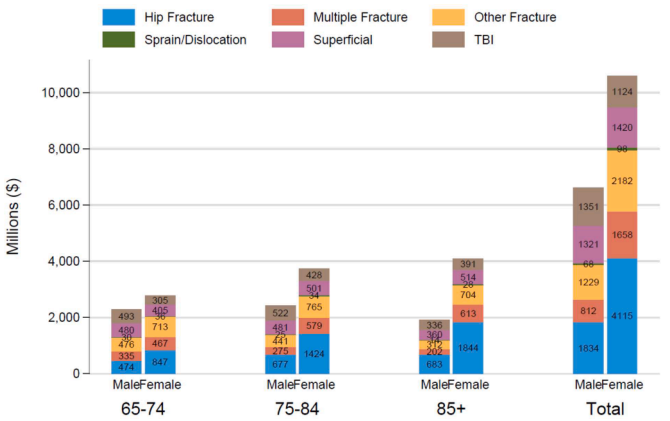


Fig. 2a. . Average Annual Total Inpatient Cost for Fall Injury by Gender, Age, and Injury, 2016–2018 (average number of annual inpatient visits in women: 596,339; and in men: 326,088).

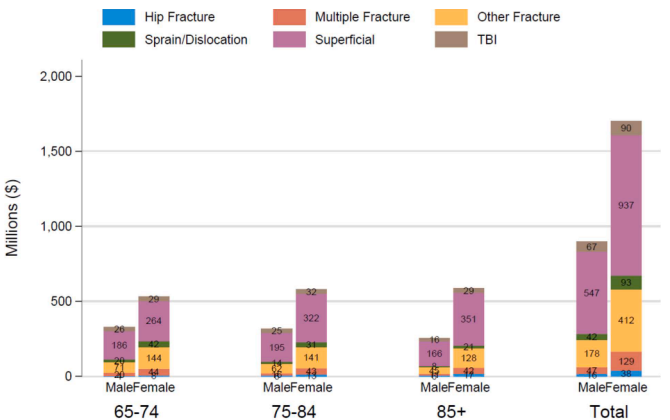


Fig. 2b. . Average Annual Total ED Cost for Fall Injury by Gender, Age, and Injury, 2016–2018 (average number of annual ED visits in women: 1547,705; and in men: 788,391).

total inpatient cost in women (\$7.9 billion). Notably, the total cost of non-hip fracture was higher than hip fracture in men 65–74 (\$810 million vs. \$474 million), men 75–84 (\$715 million vs. \$676 million) and women 65–74 (\$1.2 billion vs. \$846 million). Like trends in inpatient cost, the overall cost of fall injury in the ED was approximately twice as high for women than men with some amplification at older ages in women. Superficial injuries were the costliest injury type regardless of age, with costs totaling \$547 million in men and \$936 million in women. Notably, more than one-quarter of ED spending was for fracture totaling \$242 million in men and \$580 million in women.

Discussion

This study characterized the frequency and cost of inpatient and ED visits for fall injury among older adults in the United States from 2016 to 2018 by sociodemographic, injury, and health characteristics. Total combined inpatient and ED cost for fall injuries averaged \$19.8 billion dollars annually. Inpatient cost was driven by treatment for fracture which comprised 57% of total inpatient cost in men, and 75% of inpatient cost in women. Importantly, nearly 40% of inpatient visits were for fractures other than hip fracture speaking to the high prevalence of various types of orthopedic injury and the implications for longer term care, disability, and health care cost. **Most of the ED cost was attributed to superficial injury**, though notably 25% of total cost was attributed to fracture.

Our estimates of inpatient and ED cost were similar to a previous

study found that in 2016, \$16 billion was spent on inpatient and \$3.1 billion spent on ED visits for fall injury among adults 65 years and older. [3] Our study builds on these results by examining cost by injury type. **We found that cost of non-hip fracture (multiple fractures and other types of fractures) was higher than total cost of hip fracture in men less than 85 and in women 65–74. These findings underscore** the ongoing need for fall prevention programs [32–34] and care models that reduce treatment cost and improve care of a broader set of fall related fracture. In line with our findings, a recent study found that compared with hip fracture, other fracture types had similar or greater post-acute costs [12]. There is growing interest in multidisciplinary orthogeriatric programs, and studies have shown they improve care pathways and post operative outcomes, however most programs have focused on older adults with hip fracture [35]. Given the high prevalence of other fracture types and associated medical costs, it will be important to determine whether orthogeriatric programs are beneficial and cost effective for a broad set of fractures in the future. Moreover, while most fractures were from low energy falls, the cost of inpatient and ED visits for high energy falls (which are increasing in prevalence) were significantly higher – raising important implications for prevention, care, and recovery. [20]

We found that 60% of ED treat and release visits were for superficial injury constituting \$1.48 billion in total ED cost. More primary care physician availability in the evenings and on weekends, and use of urgent care centers may curb ED visits and reduce cost for less severe fall injury. However, the high rates of ED utilization may be an indicator of issues accessing other care resources after a fall. A recent study found that older adults with dementia were more likely to be treated and released from the ED for a fall, owing to uncertainty about fall mechanism and a lower threshold for transport to the ED by family or emergency medical services [14]. This study also found that older adults living alone and living in poverty were more likely to be treated in the hospital for a fall rather than seek outpatient care or follow up with their primary care physician.

The notable rate of injuries treated in the ED highlight an opportunity for secondary prevention efforts [36] which will be critical as the population ages to reduce the economic and health burden of fall injuries. ED-based fall prevention interventions such as GAPcare, (the Geriatric Acute and Post-acute Fall Prevention Intervention) [37] which brings together caregivers, pharmacy, physical therapy, and clinicians to provide a collaborative approach to fall prevention is a promising initiative now being tested in two academic US emergency departments. **GAPcare is designed to prevent recurring falls among people who experience a fall requiring ED care.** ED evaluations for falls primarily focus on injury assessment and do not address modifiable risk factors to prevent subsequent falls. Establishing and testing protocols for multifactorial fall risk assessment **such as GAPcare** is critical given that older adults are at high risk of recurrent falls in the post-fall period.

We observed higher per-visit cost among specific vulnerable subgroups. For example, we observed higher average ED visit cost among adults 85 years and older and for those with dementia. These individuals likely require more complex care and are at higher risk for poor outcomes. Therefore, it is critical to establish guidance, which is currently lacking, for managing older, cognitively impaired adults in the ED settings [38]. **These findings underscore the importance of ED-based fall prevention initiatives that coordinate across providers and care settings.** Interestingly, we found that the costs of inpatient visits for injurious falls were lower in the very old (adults 85 and older) compared with those in younger age groups (i.e., 65 to 7; 75–84), raising the possibility they are more likely to be hospitalized for less severe injuries. We also observed that nearly two thirds of older adults admitted to the hospital are discharged to a SNF and that visit cost were 46% higher compared with routine discharge. **Older adults discharged to a SNF are typically those with hip fractures or other fractures affecting mobility that require physical therapy before returning home.** This is an important subgroup since overall health care cost for

falls injury are much greater given that they extend beyond the acute care setting. For example, in 2016 an estimated \$17 billion was spent on nursing facility care and \$8.4 billion on ambulatory services for older adults treated for a fall [3].

The strengths of this study include a multi-year nationally representative sample which allows us to make population level estimates of fall injury and cost. **We used of ED level cost to charge ratios, which were recently made available by HCUP and which improve the accuracy of ED visit cost estimates. In the past, cost-to-charge ratios were not available at the ED level, so estimates were either not adjusted, which overstates the costs of the ED visits, or estimates used IP cost-to-charge ratios for similar hospitals, which is less precise than the recently published ED ratios.** There are several limitations. First, the data include discharge rather than patient level data so patients with recurrent admissions may be represented more than once. Second, we focused only on acute care cost and did not include outpatient services or indirect cost of informal care. While inpatient and ED costs for fall injuries have been reported in other studies, our study was unique in that we examined variation in cost by injury type and mechanism, care setting, and sociodemographic characteristics. **Third, we could not distinguish between older adults admitted to the hospital from a nursing home versus the community which may have important implications for cost and prevention efforts. Finally, data was limited to the years 2016 through 2018 which may not reflect current inpatient and ED cost for fall injuries.**

In summary, our results demonstrate that high cost of inpatient and ED visits for fall injury are driven by fracture of various types. Women and adults 85 years and older accounted for the highest proportion of falls and the highest share of resulting costs, underscoring the need for targeted prevention and intervention strategies. The number of visits and cost of inpatient and ED care due to fall injury will likely increase with population aging and merits greater attention by policy makers who can use these results to plan for and allocate resources for both prevention and treatment of fall injuries.

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Declaration of Competing Interest

Drs. Reider, Levy, Falvey, Okoye and Wolff have no conflicts to report.

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